Report

on the construction of

MOHAMMED ALY

Barrages

by

Moh. K. NABEER pasha - Mahmoud M. KARARA bey

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MOHAMED K. NABEEH PASHA

AND

MAHMOUD M. KARARA BEY

وزارة الاشغال العمومية

مكتب الوزير

القاهرة فى ١٦ ابريل سنة ١٩٣٩

رقم ١٥/٩/١٦١ — ٨٧٥٠

حضرة صاحب العزة كامل نبيه بك

يسرنى أن أقدم لكم وافر شكرى وتهنئتى على المجهود القيم الذى بذلتموه فى إعداد تقرير الموسم الأول وبعض من الموسم الثانى لأعمال قناطر محمد على . تلك المدة التى تعتبر بحق أصعب المراحل وأشدها احتياجا للمثابرة المشفوعة بالخبرة الفنية الواسعة مع الشجاعة فى مواجهة الصعاب لتؤتى أحسن الثمرات .

وأنى لأشعر بمزيد الغبطة إذ أنتهز هذه الفرصة وأنوه بما بذلتموه عزتكم وحضرات مساعديكم من رجال الوزارة — وقد كانوا جميعاً من المصريين — من المجهود المضنى المثمر المشبع بروح البذل والتفانى مما يضيف مفخرة لفن الهندسة الذى اشتهر به المصريون من قديم الزمان .

هذا ويسرنى أن يبعثوا إلىّ بنسختين أخريين من أجزاء التقرير للاحتفاظ بهما .

وتفضلوا بقبول فائق الاحترام ؟ .

(غالب)

١٩٣٩/٤/١٦

وزير الاشغال العمومية

(محمد رياض)

١٩٣٩/٤/١٦

وزارة الاشغال العمومية
مكتب الوكـــيل
للشـكنات

القاهرة فى ١١ مارس سنة ١٩٣٩

حضرة صـاحب المعالى وزير الاشغال العمومية

أتشرف بأن أقدم لمعاليـكم تقريرى عن عملية أنشاء قناطر محمـد على خلال الموسم الأول وفترة قصيرة من الموسم الثانى لغاية منتصف يناير سنة ١٩٣٨ وهى المدة التى توليت فيها أعمال المهندس المقيم لهذه القنـاطر .

وقد واجهت خلال هذه المدة صعوبات عملية جمة فى مختلف الأعمال الفنية عند وضع أساسات الهويس وبعض العيون لكل من قناطر فرعى رشيد ودمياط ورغم سابقة اشتغالى واتصالى بمثل هذه الاعمال فقد كانت هذه الصعوبات جديدة فى نوعها — غير أنى قد وفقت إلى التغلب عليها وأتممت بنجاح تنفيذ البرنامج المقرر لهذا الفصل وتم وضع الأساسات المطلوبة جميعها .

كما وقد عنيت أشد العناية بأن يكون معمل التجارب وتحليل المواد مجهزاً بأحدث الطرق العلمية ومزوداً بآخر طراز من أجهزة الاختبار ممـا أدى إلى الحصول على أبحاث ونتائج علمية قيمة يصح أن تكون مرشداً للمشتغلين بهذه المسائل .

لذلك حرصت على أن يكون تقريرى هذا متضمناً تفصيلا شاملا ووصفاً دقيقاً لمـا صادفته من صعوبات وما لجأت إليه للتغلب عليها وما وصلت إليه من نتائج مشيراً إلى ما رجعت إليه من مؤلفات الثقاة إتماماً للفائدة العلمية .

ولا يسعنى إلا أن انتهز هذه الفرصة لأنوه بمـا بذله حضرات مساعدى من رجال الوزارة وقد كانوا جميعاً بلا استثناء من المصريين ، من الاخلاص والتفانى فى العمل ممـا أذكره لهم بجميل الحمد ووافر الثناء — كما يسرنى أن أشير بالاعجاب إلى طائفة من شباب المهندسين المصريين استخدمهم المقاول واسندت إليهم أهم الأعمال فقاموا بها خير قيام إلى جانب زملائهم من الأجانب ممـا جعل الشركة تبادر من تلقاء نفسها فى نهاية الموسم إلى مكافأتهم بزيادة مرتباتهم .

وإنى أتشرف برفع التقرير إلى معاليكم فقد تجدون فيه مايستحق النشر لفائدة مهندسى الوزارة من الوجهتين العلمية والعملية .

وكيل وزارة الاشغال للشكنات
والمهندس المقيم لقناطر محمد على سابقاً
(محمد كامل نبيه)
١٩٣٩/٣/١١

INTRODUCTION

The immediate construction of the new barrages is necessitated by the inability of the existing barrages to comply structurally with the conditions, which are imposed upon them by the agricultural requirements of today and the development, which is envisaged in the future.

They are the most vital of all irrigation structures as they command the entire Delta.

The general arguments leading up to the final decision are summarised in the following paragraphs.

It is stated in "Irrigation Policy" by His Excellency, Hussein Sirry Pasha that "Owing to the present condition of the Delta Barrage, the Irrigation Department has to adopt the 4 to 1 rule when raising the upstream level at the beginning of flood every year, which requires raising the downstream level 4 cms. for every 1 cm. rise in the upstream level. Millions of cubic metres of the early flood water are thus wasted down the Rosetta and Damietta branches, in order to raise the upstream to the level sufficiently to supply the Rayahs with the discharges necessary to irrigate the sharaki area and meet the summer cultivation requirements in this period.

"When an increase in water stored for summer was being contemplated, it was found necessary to improve the condition of this barrage so that it would not fail to fulfil its function after the completion of the storage works, and also in order to control the river water and ensure its proper distribution between the zones according to their requirements.

"We have previously shown that the Rayah Behera will be unable to carry the discharge required for the lands depending on it during the critical period of the year with the present upstream level of the Delta Barrage, namely R.L. 15.70, and that the downstream level of the head regulator must be raised to 16.25 in this period, so as to enable the Rayah to meet the requirements of cultivation throughout the whole year. It follows therefore that it is essential to strengthen or rebuild the Delta Barrage to enable its upstream level to be raised during flood to 16.35; more especially since the condition of its old masonry, on the soundness of which depends the whole of Lower Egypt, is a source of danger.

The Irrigation Department has for a long time been in doubt as to the possibility of strengthening and so increasing the head on the barrage. To make sure of its soundness and take a decision in the matter, it has recently been found necessary to make an exhaustive study of its condition. The barrage was therefore tested in several places. It has been found that the building above floor level is sound and in a reliable condition and that it could be strengthened were the soundness of the foundation not in doubt. The weakness of some parts of the foundations has

been confirmed by experiments which have so far been carried out. This may perhaps mean leaving the present Barrage to be used as a road and building a new barrage for the purposes of regulator.

In 1935 a note was submitted to the Council of Ministers with the following conclusions :—

Having already determined the new head required on the Barrages, the Ministry next proceeded to find out which would be the more advisable scheme to take in hand: was it preferable to strengthen the present Barrages or to build entirely new ones. A decision on this point must be influenced by the actual condition of the structures in so far as their foundations are able to hold the new desirable head with safety. The Ministry examined the masonry works to ascertain their present condition and the study showed that the original floor had become so weak and disjointed that any strengthening would not enable it to stand the increased head when the water level was raised; more-over, the rubble stone which was built in certain parts of the floor continues to loosen in spite of frequent repair.

The Ministry, however, did not content itself only with the above results, which were established by investigation, but owing to the very special importance of the matter they sought the advice of eminent technical experts experienced in similar works. And, it charged the Firm of Consulting Engineers, Messrs. Cood, Wilson, Mitchell and Vaughan Lee, who were nominated by decision of Council of Ministers dated May 14th, 1933, to study this question of the strengthening or rebuilding of the Delta Barrages. After examination, the Consulting Engineers advised that, in their opinion, it was necessary to build new Barrages as the foundations of the present Barrages could not be relied upon.

The Ministry also formed a special commission of senior officials of the Irrigation Service to discuss the matter. After discussion, the Commission expressed the same opinion as that given by the consulting engineers.

And so, the Ministry reached the conclusion that it was necessary to build new Barrages for regulation works, with the roadway over the new Barrages designed to suit heavy traffic. The present Barrages will not be dismantled but will be retained, first as a road bridge for ordinary traffic, and secondly as an historic monument of the reign of the Great Mohamed Ali Pasha.

The works which it is necessary to carry out consist of the following:

1) To build a Barrage on the Damietta Branch between the present Barrage and the downstream weir.

2) To build a barrage on the Rosetta Branch between the present Barrage and the downstream weir.

3) To strengthen the present Maiya Bridge on the Rayah Menufi as it lies on the road between the two Barrages.

4) To build a new head on Rayah Beheri and to make a new diversion for the Rayah intake, as the actual head regulator is very old and is inadequate to pass the discharge required in the future for Behera Province when development of cultivation has advanced.

The preliminary estimate of the cost of these works amount to L.E. 2.500.000.

In these circumstances the Ministry requests the Council kindly to approve the foregoing and to authorise it to entrust the Consulting Engineers with the preparation of the preliminary designs of the new Barrage.

The Council of Ministers having approved the foregoing, the Consulting Engineers completed the designs and the works were put to adjudication.

TENDERS.

In December 1935 tenders were invited for the construction of the following works:—

a) A new Barrage across the Damietta Branch of the River Nile and a navigation lock at the east end thereof.

b) A new Barrage across the Rosetta Branch and the River Nile and a navigation lock at the west end thereof.

c) A new Canal for the intake of the existing Behera Canal and filling in a portion of the existing canal.

d) A new Canal Head Regulator for the Behera Canal and a navigation lock in connection therewith.

e) The reconditioning of the Head Regulator of the Tewfiki Canal and a navigation lock in connection therewith.

f) A reclamation and the construction of banks on the west bank of the Damietta Branch of the River Nile.

g) A new Hydraulic Research Laboratory in the vicinity of the western abutment of the new Barrage of the Damietta Branch of the River Nile.

h) The conditioning of the western ancient gateway on the line of the new roadway.

i) A new Canal Head Regulator, canal intake and road bridge on the Nagayel Canal in the vicinity of the Western Ancient Gateway.

k) A new fixed road bridge across Darawa Canal and a similar bridge across the experimental channel of the Hydraulic Research Laboratory, both in the vicinity of the west abutment of the new Barrage across the Damietta Branch.

l) New bridge with opening spans at the lock of the Tewfiki Canal Head Regulator, the new Damietta and Rosetta Barrages, and the new Behera Canal Head Regulator.

m) Roadways.

n) Sluice gates, machinery, lock gates, etc.

Tenders were opened on 7th April 1936 and are hereafter tabulated in a sequence of increasing prices:—

1) Tilbury Contracting & Dredging Co.
Company (Foreign Limited,
Baehler Savoy Building, Cairo) L.E. 2,376,037.760

2) **MacDonald Gibbs & Co. (Engineers) Ltd.** 28, Finsbury Square, London, E G. 2.	L.E. 2,486,133.406
3) **Société Générale d'Entreprises,** 56, Rue Faubourg, Paris	L.E. 2,517,235.874
4) **Schneider & Cie.,** 42, Rue d'Anjou, Paris.	L.E. 2,544,035.400
5) **Gibson & Pauling (Foreign) Ltd.** Shell House, Cairo.	L.E. 2,557,282.390
6) **John Mowlin & Co. Ltd.** 91, Ebury Bridge, Road, London S.W. 1.	L.E. 2,609,187.004
7) **Edmund Nuttal, Sons & Co.** 22, Grosvenor Gardens, London, S.W. 1.	L.E. 2,627,453.779
8) **Société Anonyme Hersent,** 60, Rue de Londres, Paris.	L.E. 2,658,771.078
9) **Sir Lindsay Parkinson & Co. Ltd.,** 171, Shaftesbury Avenue, London W.C. 2.	L.E. 2,746,365.723
10) **John Cochrane & Sons Ltd.,** 39, Victoria Street, London, S.W. 1.	L.E. 2,775,581.047
11) **Charles Brand & Sons Ltd.,** 25, Charles Street, London, S.W. 1.	L.E. 2,795,323.530
12) **Balfour Beatty & Co.. Ltd.,** 66, Queen Street, London, E.C. 4.	L.E. 2,949,113.963

Three other firms of contractors paid the necessary deposit and took the Contract Documents, but dit not tender namely :—

Les Grands Travaux de Marseilles
Julius Berger - Berlin
Maison Dyckerhoff Widman - Berlin.

The time for completion quoted in the several tenders, with the exception of Messrs. Hersent, varied between 15th October 1939 and 31st December 1939. These comply with the provisions of the 1st paragraph of Clause 136 (A) which lays down that regulation on the proposed structures shall be effective immediately after the flood succeeding the third season's work namely 1939.

Messrs. Hersent, however, quoted 10th February 1940 as their date for completion.

A careful analysis of the several offers showed that competition to get the work had been keen, and that prices had been cut and possibly in some cases to figures which raised doubts as to the ability to satisfy the standards specified and required.

The Consulting Engineers completed their examination and reported fully in due course with their recommendations, but the Ministry desirous of furthe

consideration asked the tenders to extend the validity of their offers to October 31st 1936, and to which all but Nos. 6, 10 and 11 agreed without any reservation.

On October 30th 1936 His Excellency The Minister, Osman Moharram Pasha, gave the contract to Messrs MacDonald, Gibbs & Co., and on the same date the Ministry ordered them to start work forthwith.

These Contractors had proposed in their tender to construct the Behera Regulator without driving a steel sheet pile diaphragm around the site, and as the latter was considered to be necessary for the satisfactory execution of this section of the works on account of the subsoil water and the risk of slips, the Ministry before assigning the contract asked them if they were prepared to drive that diaphragm. They stated the following in a letter to H.E. The Minister :—

"In the construction of the Behera Regulator, we have no objection, if the Government so desires, to driving a sheet pile diaphragm around the site without extra cost".

NAMES OF THE DIRECTORS OF THE COMPANY.

Lieut. Colonel A.C. MACDONALD D.S.O.
M.I.C.E. Chairman.

A.G. PEARS Esq.,

R.B. BANNON Esq.,

F.H. BURKITT Esq., C.I.E., O.B.E.

The latter who is the Chief Engineer of the Company was appointed as their resident Director and Agent of the works.

FINANCIAL ABILITIES OF THE COMPANY.

The National Bank of Egypt, gave the following information to the Ministry with regard to the financial abilities of the Contractor :—

> "With reference to the tender for Mohamed Ali Barrages which will be submitted by Messrs, MacDonald, Gibbs & Co. (Engineers) Ltd., 28, Finsburg Square, London, E.C. 2, we have the honour to inform you that to the best of our knowledge and belief the financial situation of Messrs. MacDonald Gibbs & Co. (Engineers) Ltd., is sound and that they are financially able with their own means and financial assistance assured to them to carry out the contract of the Mohamed Ali Barrage for which they intend tendering".

GENERAL SCHEME OF PROCEDURE.

The Contractors submitted the following notes with their tenders to cover the general scheme to be adopted, the waterways to be left open at the various seasons, and the special design of the main and pitching sudds.

METHOD OF PROCEDURE.

1. ROSETTA AND DAMIETTA BARRAGES

The method of procedure for the construction of the Rosetta and the Damietta Barrages is, in the opinion of the contractors profoundly effected by the width of waterway to be left for riverflow in the second and third seasons.

The Contractor's method of computing the necessary waterways is, for facility, put in the form of a separate note, which with its diagrams and table is attached as Appendix 1. They believe that this method utilises the latest knowledge obtainable on this subject. The result appears to offer two alternatives :—

a. To delay the completion of the sudds in the second season and adopt a much heavier programme in that season,

or

b. To complete the sudds early and make the third season the heaviest

The contractors in their programme adopted the second alternative as it is considered to be easier to get increased progress in the third season rather than in the second. Moreover, in the third season the abutments and as many vents as are desirable can be independently constructed from materials stored during the previous flood period on the abutment bank. The bulk of the work would be fed from the lock bank.

ROSETTA BARRAGE

First Season

It is proposed to start driving the sheet piles for the 15th November 1936 by which time river level is not likely to be higher than + 16.00 m. With three floating pile drivers, working two shifts, this operation would be completed by 31st December.

As the sheet piling advances the material for the sudds will be deposited on both sides of the completed portions of the pile lines. The programme shows such deposition as starting by 5th December, i.e. three weeks after starting pile driving.

In the first season the material for the sudd will be obtained from the right bank which requires excavation. This excavation will be done down to water level by hand and transported to the sudd by boats and below water level by suction dredger. The sudd is shown in the programme as being finished on the 31st of January.

A description of the layout and design of the sudds is given in a separate note, Appendix II and need not be dealt with here.

Pumping will be started a week before the absolute completion of the sudd and will be carried on for a fortnight, the sudd being brought to its designed section as the water level within the sudd drops.

Pumping will initially be carried out by means of 12" pumping units carried on pontoons. Once the enclosures were emptied the area will be kept dry by means of pumps on sumps in the two main drains upstream and downstream of the work as described in the note on the sudds. As soon as the enclosure is emptied, at the end of the first week of February, excavation of the foundations will be started and will be pressed to completion by 15th March so as to complete the driving of the permanent sheet piles as quickly as possible and leave the area free for concrete laying. The excavated material will be placed on the sudds for platforms for concrete mixers and track as necessary. The pile driving will start one week behind the excavation and will be completed by the 25th March, i.e. one week after the completion of the excavation. The laying of concrete will start on the first March, i.e. a fortnight after starting the sheet piling and will be laid, at an average rate of 440 m^3 per day of two shifts until 30th June. It may be mentioned that in all computations a month is taken as equivalent to 25 working days. The granite masonry will progress with the laying of the concrete at an average rate of 23 m^3 per day of two shifts, up to flood level. The rest of the superstructure will be completed during the flood season. For most of the first season the cableways, which will be used throughout the second and third seasons, will not be ready for work. Accordingly the concrete mixers will be placed inside the sudd, but at sufficient distance behind them to prevent any trouble from seepage water at the level of the narrow guage track below the mixers. These concrete mixers will be connected by platforms to the sudd, thus allowing of their being fed direct from narrow guage tracks laid on the top of the sudd and connected with the aggregate stacks, cement sheds and concrete block stackyard.

Moulding of the concrete blocks started on the 15th November will be completed by the end of February. Placing of the limestone loose rubble will start on the 15th March, i.e. when the excavation is finished and will continue until the 15th June. The placing of the blocks will start a fortnight after starting rubble pitching and will finish on the 30th June. The average number of blocks placed per day will be 22.

The programme on which these computations are based allows for the completion of the lock and 1½ vents. As explained on the accompanying note on the sudds the first season's sudd is laid out to admit of four vents being constructed if conditions are favourable.

The excavation of the right bank will, of course, start simultaneously with the filling of the sudd, i.e. at the end of the first week of December. As soon as the

main sudd has been completed from this source, part of the remaining excavation will be used for forming sudds for the construction of the right bank pitching. The programme shows this pitching, except in the vicinity of the abutment, as being finished by the 15th June. The reason why it is proposed to do the right bank excavation and pitching during that first season is to provide sufficient waterway for the river during the early part of the second season.

The portion of the left bank pitching, upstream and downstream of the lock enclosed within the main sudd will be also done during this season.

The sudds will be dismantled during July, the piles being extracted by three powerful machines, working three shifts per day if necessary.

Second Season

During the second season the procedure is generally similar but, owing to the construction of the river, the completion of the sudd is not effected until the 15th February and, in consequence, all succeeding work starts somewhat later than in the first season. During this season the material for the sudds will be obtained from suction dredgers located 300 metres downstream of the weir.

It is proposed to complete up to the 22nd vent this season and the necessary progress per day is shown in the attached programme.

During this season, concrete and all material will be handed by means of cableways supplemented, where necessary, by narrow guage tracks ramping down from the sudd. The remainder of the left bank pitching will be completed during this season between the first March and the 15th June.

Third Season

The general programme for the third season is similar to that of the second season save that the excavation and all other work has been speeded up. As previously explained the abutment and as many vents as are desirable will be independently constructed from materials stored during the previous flood period on the right bank, the bulk of the work being fed from the left bank. By this method of procedure the quantities of concrete and materials to be handed by the cableways during the third season will be approximately the same as during the second season.

DAMIETTA BARRAGE

The programme for the construction of the Damietta Barrage is generally similar to that of the Rosetta Barrage and it appears to be sufficient, subject to the following remarks to draw attention to the diagrammatic programme attached. The characteristic features of the sudds are referred to in the note on the sudds. The only point to which attention need to be drawn is the proposal toe do, during the first season, all the upstream left bank pitching, down to the inner toe of the third season's sudd. All pitching below the latter point will be done during the third season.

For this barrage also cableways will be used and will be supplemented as regards supplies, during the third season by materials stacked on the left bank, during the previous flood season.

2. BEHERA HEAD REGULATOR AND CANAL

First Season

It is proposed to start the excavation for the Regulator on the 1st October of the current year, taking up a length of approximately 260 metres so as to include the downstream pitching in the excavation pit. The average speed of excavation will be approximately 1,000 m^3 per day. By the 1st March the excavation for the Regulator proper will be sufficiently advanced to admit of starting the sheet piling. By the end of May 1937 the excavation will be completed and laying of concrete will start on the first June. The sheet piling will be finished by the end of the first week in August and the concrete and masonry will be finished by the end of February 1938. The concrete blocks will be moulded and laid as shown on the programme. The period from June to February has been chosen for the construction of the Regulator so that plant, labour and staff can conveniently be transferred from the Barrages.

The excavation for the Regulator will be done completely in the dry and a substantial ring bank will be constructed round the excavation pit in order to prevent any risk of flooding during the high river months.

Starting on the 1st December, small sudds will be constructed round the junction points of the side pitching and the river, at the entrance to the new canal vide note on sudds. These sudds will permit of the construction of the side - slopes pitching at the entrance of the new canal and down as far as the key of natural ground at the upstream end of the Regulator pit.

All the pitching immediately upstream and downstream of the Regulator save for that under the upstream key, will be finished by the end of February 1938, i.e. when the Regulator is finished.

After taking steps to block the channels which have been excavated for the upstream side pitching near the river, the upstream key will be removed and the pitching at this place completed.

Below the downstream key, excavation of the canal will start on the first June 1937 and the excavation of the canal upstream will start when the pitching at the key has been completed, viz. on the 1st May 1938. Save for the key on the river face and for the key between the new and old canals, the excavation of the new canal will be completed by the end of November 1938. The moment the existing canal is closed, in the end of December 1938, the key between the canals will be quickly removed, the material being used, as much as is suitable, for the construction of the pitched slope across the old canal. The method of constructing, in the time.

available, the pitched slope across the old canal has been very carefully considered. It is proposed to lay the material for the slope in layers, well rammed and consolidated, so that the pitching can follow closely behind the construction of the earth slope. The pitching above canal water surface will be done after the new canal has been brought into operation.

The filling of the existing canal will be proceeded with and completed by the end of June 1939. Miscellaneous pitching, i.e. at the entrance of the existing canal, between the mouths of the canals and along roads and banks will be constructed as found convenient.

3. TAWFIKI REGULATOR

During the canal closure, in 1937-1938, the underwater work of reconditioning the Tawfiki Regulator will be undertaken. The sudd at the entrance will be constructed at the maximum possible speed as described in the separate note on sudds. The work above water level can then be proceeded with as found convenient.

4. NAGAYEL REGULATOR

The new mouth of the canal will be constructed in the first season, behind the sudd for the pitching on the river bank. The mouth will be then securely blocked.

The temporary diversion of the canal will be started about October the 1st 1937, and completed in the beginning of the closure period of the canal.

The regulator will then be constructed and completed in the early part of 1938 to obviate interference with the construction of the abutment of the Rosetta Barrage in the third season.

5. HYDRAULIC RESEARCH LABORATORY

The entrance of the experimental channel will be constructed during the first season with the pitching on the left bank of the Damietta Branch, upstream of the new barrage. The outlet of this channel will be constructed during the third season, when the sudd required for its construction will be masked and protected by the main third season's sudd for the Damietta Barrage.

The rest of the work in connection with the laboratory will be constructed as found most convenient.

6. REMAINING SUBSIDIARY WORK

The construction of the Road Bridges, the Ancient Gateway and the Roads are hardly affected by river conditions and will therefore be carried out as found most convenient.

TOOLS AND PLANT

The materials for the sudds will be largely obtained by suction dredgers. The sheet piles for the sudds will be driven by floating pile driving plant. The same plant, after conversion for working on land, will be used for driving the permanent piles. Some of the larger pumps will be diesel-electric driven and mounted on pontoons for the initial dewatering of the areas enclosed by the sudds and to cater for any temporary stoppages of the electric current supply. Cableways for handling the concrete and the various materials for the construction of the Rosetta and Damietta Barrages will be erected as soon as possible.

Ample provision of broad and narrow guage railway track, of locomotives and rolling stock has been made for handling the various materials.

Ample provision has also been made for cranes and derricks up to 10 tons capacity for handling materials, for constructing masonry and for stacking and laying the concrete blocks.

In the moulding yard for the latter it is proposed to use a travelling gantry and a concrete mixer fitted with a conveyor.

Necessary provision has been made for tugs, launches, pontoons and other river craft.

One main workshop with all the necessary outfit will be erected on the left bank of the Rosetta Branch. One subsidiary workshop will be built on the right bank of the Damietta Branch and a smaller workshop at the site of the Behera Regulator.

Four installations for water supply, including wells and tanks, have been provided at each of the sites of the three main Works and at the colony.

APPENDIX I.

NOTE ON WIDTHS TO BE LEFT FOR THER RIVE FLOW

The attached table shows the discharges of the Rosetta and Damietta Branches of the Nile on the 1st and on the 15th of each month from October to March for the past five years.

The discharges in this table are given in million of cubic metres per 24 hours; to convert these discharges into cusecs, the figures should be multiplied by 405. The diagrams attached show the graphs of these discharges in cusecs.

For a channel in regime, flowing in its own alluvium, the relation between wetted perimeter and discharge is generally admitted to be the best established of Lacey's formula which were first published in paper No. 4736 of the Institute of Civil Engineers entitled "Stable Channels in Alluvium"

Since the publication of this paper, Lacey's formula for this particular relationship has been checked by observations on countless channels in the Punjab and North West Frontier province in India and, so far as is known, no descrepancy has been found in the case of a stable channel.

The formula has been found, by observation, to hold good not only for the finest grades of sand but also for gravel and large boulders.

In the North West Frontier Province in India and probably in other Provinces also, Government has adopted this formula for designing widths of waterway for rivers flowing in their own alluvium. The few observations made on the Nile also show agreement with the formula.

This formula is :—

$$P = 2.668 \sqrt{Q}$$

where P = Wetted Perimeter in feet.

Q = Discharge in cubic feet per second.

If a width greater than that given by this formula is adopted, it is found that the berms silt up, while a smaller width causes scour of the berms unless they are protected. If they are protected then increased bedscour results. For all but small widths the wetted perimeter may be taken as equivalent to the surface width.

In designing the sudds, for safety, widths between the toe of the sudd and the river have been taken intead of the surface width.

No advantage would be obtained as regards velocities and depths of scour by adopting greater waterways as the river would automatically adopt its correct section by silting the berms and scouring the bed.

The date for the completion of the second and third season's sudds is shown on the programme as the 15th February. On the 5th of February the maximum discharge has dropped to 25,000 cusecs, which would require a surface width of 126 metres. In a fortunate year this discharge obtains on the 15th January. After the 5th of February the discharge rapidly drops. Accordingly in the third season a width, between the toe of the sudd and the river wall of the lock, has been shown as 12 vents or 126 metres. In the second season a width equivalent to 13 vents has been provided in case the excavation for the side pitching should not be completely done.

In the case of the Damietta Branch, from 15th of December to the 1st of February a surface width of about 90 metres is correct. After the 15th February a surface width of about 575 metres is indicated.

The date for the completion of the second and third season's sudd is shown on the programme as the 1st February, when the discharge is about 10,000 cusecs for which a surface width of 81 metres is required. The design provides for a toe width of 84 metres. In a fortunate year this width would be sufficient after the 1st of December.

We attach hereto a special note on the hydraulic conditions at the Damietta Barrage in the third season. The conditions at the Rosetta Barrage need not be considered as there is only seepage flow after February.

TABLE SHOWING THE DISCHARGES, IN MILLIONS OF M^3 PER 24 HOURS OF THE ROSETTA AND DAMIETTA BRANCHES ON THE 1st AND 15th OF EACH MONTH FROM 1st OCTOBER TO 14th MARCH.

	31 — 32		32 — 33		33 — 34		34 — 35		35 — 36	
	R	D	R	D	R	D	R	D	R	D
Oct. 1	270	130	314	140	262	142	321	133	388	165
15	360	150	400	164	286	147	267	155	374	158
Nov. 1	235	130	260	127	255	137	275	135	340	141
15	190	100	166	110	205	115	169	50	124	68
Dec. 1	80	70	76	70	69	28	69	32	44	30
15	30	30	19	25	40	36	19	29	33	29
Jan. 1	63	26	83	15	86	39	88	15	81	25
15	59	22	81	25	79	30	76	28	80	25
Feb. 1	20	30	22	30	71	25	72	27	78	23
15	12	8	30	11	10	12	15	18	14.7	10.5
Mar. 1	0.2	—	0.2	12	0.2	15	0.2	14.4	0.2	11.5

R = Rosetta Branch.

D = Damietta Branch.

NOTES ON HYDRAULIC CONDITIONS AT DAMIETTA BARRAGE IN THIRD SEASON

Maximum Discharge on 1st March = 14.81 10^6 M^3 per 24 hours = 600 cusecs in British Units.

Length of existing weir left open = 120 m = 384 feet.

$$\text{Discharge per foot run} = \frac{6000}{384} = 15.6 \text{ cusecs}$$

If H is the height, in feet, from sill of weir to water surface upstream.

$$H = \frac{15.6}{3.09}^{2/3} = 2.943 \text{ feet}, = 0.897 \text{ M.}$$

∴ Water surface between existing weir and new Barrage = 12.69 + 0.897 = +13.587.

The intensity of discharge through the 8 vents left open

$$= \frac{6000}{8 \times 8 \times 3.28} = 28.57 \text{ cusecs.}$$

If the height, in feet, from the sill of the vents to upstream and downstream water surfaces be denoted by H_1 and H_2 respectively, the "drowning ratio" = $\frac{H_2}{H_1}$

The coeficients of discharge in the formula

$$Q = CH_1^{3/2}$$

vary considerably once a drowning ratio of 0.667 is passed. Up to a ratio of 0.667, C has the constant value of 3.09 and a standing wave occurs downstream of the sill. As the drowning ratio increases, the standing wave disappears and the flow becomes smooth.

With drowning ratio above 0.667 the coefficient, C, is higher with gentle than with rapid divergencies.

For various drowning ratios, the coefficient C, will have values approximating to those given in the following table, but somewhat higher, as the divergence is very gradual in this case, the slope of the glacis being 1 in 26.8.

Drowning Ratio.	0.70	0.75	0.80	0.85	0.90	0.99	0.96	0.97
C	3.09	3.085	3.07	3.025	2.83	2.39	2.25	2.15

Water surface level downstream = 13.587 and the sill of the Barrage is at level 12.00.

so that H_2 = 1.587 metres = 5.205 feet.

Taking a drowning ratio of 0.96 and coefficient of 2.26, $H_1 = \frac{5.205}{0.96} = 5.42$,

and the discharge per foot run = $2.26 \times 5.42^{3/2} = 28.57$ cusecs, the discharge required

There will thus be no standing wave and the level of water surface upstream will be 5.42 feet or 1.652 metres, above the sill of the Barrage, i.e. at level + 13.652 and the drop in water surface through the Barrage will be 0.065 metres = .213 feet = 2 1/2 inches.

Depth of scour between new Barrage and existing weir in the case of the third season at Damietta Barrage

In an elliptical channel, if D=Central Depth and A = major semi axis, the value of D is given by

$$D = \left\{ \frac{Q}{1.4CA} \right\}^{.6} \quad \text{in British Units.}$$

For a straight channel.

The coefficient C depends on the coarseness of the alluvial bed.

From specimens of the bed silt examined it is thought that the silt is certainly coarser than, what in india, is known as a "0.9 Grade" of silt. Taking this value, $1.4C = 1.4 \times 0.9 \times 0.84 = 1.06$.

The width is 85 metres or more, say 280 feet, so that A=140 feet, Q=6000 cubic feet per second.

$$\therefore \; D = \left\{ \frac{6000}{1.06 \times 140} \right\}^{.6} = 40.4^{.6} = 9.2 \text{ feet} = 2.805 \text{ metres}$$

Surface level	= + 13.587
Deduct	2.805
Deepest Scour level	= + 10.782

which is 0.782 metre above surface of the concrete blocks and 2.282 metres above bottom of rubble below blocks.

APPENDIX II.

NOTE ON THE DESIGN OF THE SUDDS. MAIN SUDDS - ROSETTA AND DAMIETTA.

Though costly, the design of the proposed sudds has the merit of extremely flat hydraulic gradients. In the opinion of the Contractors the adoption of the flat hydraulic gradient greatly simplifies the whole work and the tasks of pumping and dealing with springs are reduced to a minimum.

The cross sections of the sudds submitted show a hydraulic gradient of 1 in 12 from maximum recorded River level on the 15th February to water surface level in the main drain parallel to the work. No pumping will be permitted between this drain and the sudd. The water surface level in the drain has been taken as 1 metre below the lowest foundation level of the permanent work in order to provide for the necessary slope in any subsidiary drains that may be necessary. This main drain has been kept some 20 metres away from the edge of the permanent work.

In actual practice the hydraulic gradients will be much flatter as, by the time the foundations have been excavated to the full depth, the River levels will have dropped by 0.75 metre in the case of the Rosetta Branch and by 0.9 metre in the case ot Damietta.

A line of sheet piling, from 9 to 11 metres long, will first be driven and the sudd then formed on each side of it, the bulk of the sudd being on the inner side of the line of sheet piling, as indicated on the cross sections of the sudds.

The minimum length of the piles will be 9 metres but a greater length will be used either when the surface level of the river is high, as in the second half of November, or where the bed of the river if specially low so as to give sufficient embedment during the deposition of material on both sides of the sheet piles. If necessary, as River level drops, the piles will be re-driven deeper.

The proposed lay - out of the main sudds is shown on plans Nos. 1 & 4. As explained later, it is proposed to excavate for, and to lay the pitching inside temporary sudds constructed in compartments.

In the case of both Barrages to first season's sudds enclose sufficient area to construct the lock and four vents, though the programme allows only for the lock and one and a half vents. If things go well four vents will be contructed but, as team work will not be so good the first season as later on, an ambitious rate of progress has been assumed.

The second season's programme in limited by the width of waterway to be provided for the river discharge and the method of arriving at this width is given in Appendix I.

Similarly, the third season's programme and lay - out of sudds follows automatically.

No difficulty is anticipated in the construction of the first season's sudd for the Rosetta Barrage where the ends of the sudd will be tied into the River Bank. The second season's sudd will be tied into the bank on top of the constructed pitching - in - mortar and special precautions will be taken to prevent the seepage of water along the joint between the sudd and this pitching and, for additional safety a gravel filter will be provided at the inner toe of the sudd in the vacinity of this joint.

The third season's sudd presents peculiar difficulty where it crosses the completed work and more particularly where it crosses the permeable apron of concrete blocks resting on loose stone. If permitted by the Consulting Engineers, the Contractors will construct a series of this impermeable diaphragms in the loose stone or take other measures, as may be approved, to decrease the leakage along this aprons but the design submitted relies entirely on the very flat hydraulic gradient of about 1 in 20 (or 1 in 24 after the 25th February) and on gravel filter at the toe of the sudd. It is considered that complete security is obtained by means of a gravel filter whatever may be the amount of seepage. The Contractor's Chief Engineer has on four separate occasions successfully passed the whole winter's supply of the Sultej River through a gravel filter. The flood discharge of this river is about the same as that of the Nile though its winter discharge is somewhat less. He has also done the same in the case of a large branch of the Indus River. The greater the leakage, the greater will be the amount of water to be pumped but security against failure of the sudd is ensured.

In the case of the sudds for the Damietta Barrage where it is necessary to cross a permeable floor every season it is proposed to adopt the same method of gravel filter toe even where it may be possible to drive sheet piling across the permeable parts.

As shown on the plan of the Damietta sudds and in the cross section on the same plan, it is proposed to tie the transverse sudd on to the existing weir and to construct a bank, as shown on the existing weir. On account of the lower water levels downstream of this weir, the head against this bank is almost negligible.

Before completion of the sudds, both in the case of the Rosetta and Damietta Barrage in the end of January of the third season, the velocities in the constructed channel over the completed portion of the Barrage will probably be high enough to prevent the deposition of material for the sudds if unprotected. It is, accordingly, proposed to construct a continuous cone of sandbags, gravel or rubble along the face of the sudd parallel to the river and then deposit the material for the sudd behind this protection as indicated on the cross section.

In estimating the quantity of material required for the sudds an allowance of 20% has been made, in excess of the quantities corresponding to the ideal sections, for sloughing and wastage.

Sudd for pitching.

In order to obviate the enclosure of enormous areas by the main sudd, the Contractors propose to enclose the areas along the river banks which require excavation and pitching by means of temporary longitudinal and cross sudds.

These sudds, which have no relation to the main work, are designed of lighter section than the main sudds and without any sheet piling. They have been designed for a hydraulic gradient of 1 in 7 from the river level of the 15th February and, by the time excavation is completed, the hydraulic gradient will be flatter. The Contractor's Chief Engineer knows of no case where a sudd, even when composed of the finest sand, has failed when designed for a hydraulic gradient of 1 in 7 and where the sudd has not acrossed a permeable stratum such as pitching.

Where the accross and partition sudds tie on the completed pitching, special precautions such as driving sheet piles and laying the pitching in mortar will be odopted.

This method of laying the pitching behind their own separate sudds has many other obvious advantages.

SUDDS FOR PLACING THE PITCHING AT THE ENTRANCE TO THE NEW BEHERA CANAL.

It is proposed to construct the pitching of the sides of the new Behera Canal, where the latter meets the river, behind sudds of similar design to those for the pitching of the river banks upstream and downstream of the two new Barrages.

These sudds are indicated on plan No. 7.

SUDDS FOR RECONDITIONING THE TAWFIKI HEAD REGULATOR.

The plan and section of the sudd for reconditionning the Tawfiki head regulator are shown on plan No. 7. The material for this sudd will be collected at site, it being possible that part may be stored on the left bank but the main portion will be in barges to admit of the construction of this sudd at great speed. Special precautions will be taken at the ends of the sudd where the latter meets the existing pitching upstream of the Regulator.

SUDD FOR THE MAIN OUTLET OF THE HYDRAULIC LABORATORY CHANNEL.

The plan and section of the sudd proposed for the construction ot the main outled of the Hydraulic Laboratory Channel are indicated on plan No. 7.

This is a small sudd and will be of similar design to the sudds for executing the pitching up and downstream of the Barrage.

This will be constructed in the third season when the sudd will be masked by the main third-season sudd for the construction of the Damietta Barrage and will not therefore need protection against face scour.

MODIFICATION OF 1st SEASON'S PROGRAMME

Before starting work the Contractors modified the 1st season's programme which had accompanied their tender. This modification was due to the late date on which the contract was awarded to them. They intended by their revised programme to complete during the 1st season the locks of Rosetta and Damietta Barrages, the pitching in mortar of the side slopes of Rosetta left bank within the limits of the area enclosed by the temporary sudd, and to carry out the excavation of the intake of Rayah El Behera together with the pitching for the noses and the bank upstream the Regulator. It will be shown hereinafter that the Contractors failed to complete this modified programme.

PRELIMINARY WORKS.

Work undertaken by the Governement:

Early in the year 1935 - 1936 buildings for the offices of the R.E. and his staff were constructed on the left bank of Rayah El-Menufi at a distance of about 700 ms downstream its head regulator.

Three other houses were built, one for the Resident Engineer, the second for the Deputy Resident Engineer and the third to be used as a rest house for Senior visitors.

Nine other blocks were built for the accomodation of the Assistant Resident Engineer, married Engineers and masonry Inspectors of different grades. Some of the existing buildings were remodelled for the accomodation of checkers, draftsmen, the chief accountant and clerks whose services would be required at any time of the day.

A block was built by the side of the office buildings for the cement laboratory and another for a photographic studio.

Other blocks were built for the accomodation of servants, but as these came within the alignment of Rosetta right bank where pitching would be made, the Ministry of Public Works agreed to the request of the Contractors to demolish them and build new ones at their own sxpence outside the area of the permanent works.

The new blocks are located on the east side of Nagayel Canal. The doors, windows and roofing materials of the demolished quarters were used in the new ones.

It is intended to remodel these quarters as soon as possible to accomodate more checkers necessary for the supervision of the different parts of the works.

A garage and a store were built in the vicinity of the office building, the cost of the above mentioned buildings amounted to L.E. 35,000.

Branch railways.

On the east side of the Damietta Branch of the river a branch railway (called the Damietta siding) was constructed from a point north-west of the existing railway swing bridge over the Tawfiki Canal to the land allotted to the Contractors, to give access to the central stores and workyard of this part of the works.

On the south side of the existing Behera Canal another branch railway (called the Rosetta siding) was constructed from Manashi Railway Station and continued across the existing Behera Canal—by means of a temporary swing bridge of 72 metres span—to the southern boundary of the land allotted for the Contractors to give access to the Central Stores and work-yard allotted for that part of the work.

These two branch railways were constructed by the Egyptian State Railways on behalf of the Government and cost about L.E. 4600. Work on them was finished on 1st May 1937.

Handing over stations.

A handing over station consisting of two lines of railways was constructed on each siding close to the boundaries of the Contractors workyards. The Egyptian State Railways have to shunt the wagons into the handing over stations where the Contractors pick them up and vice-versa.

Work undertaken by Contractor.

On the 12th November 1936 the lands shown on contract drawing No. 2 were handed over to the Contractors where they build their offices and their dwellings, which were ready for use in March 1937; other houses were built near Behera Head Regulator site for the accomodation of some of the Contractors staff. Additional blocks were added for the sub-Contractors for the steel works.

A hospital was erected in accordance with the requirement of the Egyptian Public Health Ministry and a drawing shows the accomodation in detail. The equipment of surgical and medical appliances and the necessary medicines were supplied ready for use on June 1937. The Contractors employed a medical practitioner who was in charge of the hospital, and who resided at the site of the work in a specially built house.

The Contractors provided a first-aid dressing station at each of the Rosetta, Damietta and Behera works, and one motor ambulance.

An artesian well was sunk in the Contractors'colony for the supply of drinking water and for their gardens a pump was installed on Rayah El-Menufi on its right bank opposite to the colony.

In addition to the telephones in their colony, others were installed at the Rosetta and Damietta works. They also interconnected six of the Resident Engineer's offices, the house of the Resident Engineer, the houses of the Deputy Resident Engineer and the Assistant Resident Engineer.

Two workyards were constructed, one on the east side of Damietta Branch (see drawing) and the other on the west side of Rosetta Branch (See drawing). Each of these yards comprises a blockyard provided with a gantry. crane, a workshop, a cement shed, an electric sub-station and other petty shops Rosetta siding and Damietta siding were run through Rosetta and Damietta cemen sheds respectively. Catchment drains were excavated round these yards to receive infiltration water which drained freely or was pumped into the river whichever was necessary.

A railway subway under old Damietta Barrage Road was constructed by the Contractors to connect Damietta workyard with the Nile upstream the existing lock See drawing and photo.

An electric sub-station was also erected for Rayah El-Behera works.

OUTFITS OF ELECTRIC SUB - STATIONS.

Damietta.

2 Diesel «La Meuse»	100 HP each.
1 Diesel «Moers»	100 HP »
3 Transformers	300 K.V.A. »
3 Alternators	380 volts.

Rosetta.

2 Diesel «la Meuse»	100 HP »
2 Transformers	380 volts.
1 »	220 »
2 Alternators	400 »

Behera.

2 Diesel «La Meuse»	100 HP »
2 Transformers	380 K.V.A. »
1 Alternators	380 volts.

See photo of electric sub-stations.

The alternators are provided for use emergencies only. The main electric power for the whole work is being supplied by the Société Egyptienne d'Electricité

near Shoubra at a distance about 15 kilometers south of the Barrage. The voltage of the main current is 1000 volts and is transformed at the Barrage to 380 volts for works and 220 volts for lighting.

The following table shows the average electric power consumption per day in kw hours at different works during May 1937 by which time infiltration water had reached its maximum :

	Damietta	Colony	Rosetta	Total
Pumps	11510	220	22655	34385
Mixers	130	—	1330	1460
Lighting	1480	260	1940	3680
Cranes	295	—	1000	1295
TOTAL	13970	480	28000	42450

PLANT, TOOLS AND MATERIALS FOR TEMPORARY WORK.

Owing to the delay in awarding the contract to the Contractors, they had not enough time to prepare for the supply of sufficient plant, tools and material so as to make an early start on the works. The following lists gives the plant, tools and materials which were on site :-

PLANT AND TOOLS SUPPLIED UP TO 31st JANUARY 1938.

ROSETTA.

Description	Total	Value
Steel Barges	12	7273
Tugs	3	4300
Rowing Boats	3	18
Steam Cranes	6	3900
Steam Derricks	4	2360
Centry Crane for Blockyard	1	2744
Decauville waggons	38	320
Flat Boggies 90 cms.	53	408
» » 60 »	25	238
4T platform wag. 60 cms.	15	45
5T Tipping trucks	1	40
1 m3 » » 90 cms.	8	106
Rail Benders	2	8
Steam locos 4' 8 ½"	3	3048
Do. 90 cms. guage	—	—
Cwynne pumps & Mot. 12"	2	767
Do. 8"	2	340
Do. 6"	3	435
Do. 4"	7	425
Do. 3"	3	168
10" pumps	2	32
Customs & Freight on above	—	714
Ransoms & Carton mixers	19	5624
Cust. & Fr. on above	—	268
Caterpiller Power unit	1	346
Floading Crane.	1	2000
10 HP Electric Motor	2	75
16" Centifugal Pumps & Motor	1	216
Pile Driving machine complete	2	2130
Cust. & Fr. on above.		856
Filter pump equipt		2290
Workshop Machinery		1114
Blockmoulds	122	1366
Fittings for above		483
Concrete Skips	2	36
Carried forward L.E.		44513

Description	Total	Value
Brought forward L.E. . .		44513
Stone crusher	1	316
Cust. & Ft. on above		102
Pulsometre centrifugal pump	2	174
45HP Motors for above	2	149
Diesel Motors	2	1076
Alternators	2	285
Transformers & Start	4	585
Air receivers	2	77
Ashlar Skips	45	360
Hydraulic wheel Press	1	35
Grouting Pump	1	110
Steam Hammers	2	660
Steel Bulkheads	2	70
Mixer Winget with hopper	1	270
Lister pump	1	120
Limax pumps & Motor	3	140
8" Pump Ganz with Motor	2	228
Motor cars	3	559
1OT. Cranes	1	770
Pile extracting Gear	1	100
Pairs of wheels with axles	14	51
Rotary Screeners	2	400
Steel Trestles	4	850
Battery Rectifier	1	19
Spares for B.G. Locos		138
Compressors	2	1123
Renoto Automatic Skips	2	155
Parts for Cranes		250
Tipping Buckets	60	320
Sand Pumps	2	259
Parts for elevating Hopper Mixer		125
Pile Driver on Floating Pontoon	1	1767
Sulzer Pump 8"	1	68
Flat Boggies Chassis	21	192
Flat Trucks B.G.	17	510
Pump 4"	4	300
» 6"	2	290
Carried forward L.E.		57606

Description	Total	Value
Brought forward L.E. . .		57606
330HP Diesel Motor & Alternator	1	2424
Hand Derrick	1	100
Electric Motors & Starters	2	231
5T Smith Crane	1	410
Pumps Chauvier	10	100
Steel Centering Arches		2942
Sand Pump 5"	10	816
Low Pressure Pumps 4"		
Small Starters	10	75
Mather & platt pumps 6"	5	280
Electric Motor 1 ¾ HP. 10 HP. 15 HP.	21	210
Decauville Chassis 90 cms.	9	45
« » 60 »	25	125
TOTAL L.E.		65364

PLANT AND TOOLS SUPPLIED UP TO 31st JANUARY 1938.

DAMIETTA.

Description	Total	Value
Suction Dredger	1	3000
Bucket Dredger	2	7000
Steel Barges	6	4000
Native Boats	4	267
Rowing Boats	4	24
Floating Potoons & Pile Frame	—	—
Coal Barges	2	240
Hand Derricks	—	—
Steam Cranes	7	3870
Steam Derricks	4	3000
Gantry Crane for Blockyard	1	1755
Decauville Waggons	146	1235
Flat Boggies 90 cms.	43	285
4T Platform Waggons.	10	30
5T Tipping Trucks 90 cms.	38	1525
1 M3 » » 90 cms.	69	910
Rail Benders	3	12
Motor Cars	7	1329
» Trucks	4	879
» Ambulance	1	220
Steam Loco 4′ 8 ½″	1	986
» » 90 cms.	4	2386
Gwynne Pumps & motors 8″	2	340
Gwynne Pumps & Motors 6″	4	580
Do. 4″	4	301
Do. 4″	4	227
Freight & Customs on above		714
Centrifugal Pump Mathor & Pitt	1	69
Do. Sulzer	1	68
Pulsometres	4	50
Ransomes & Carton Mixers	9	3300
Customs & Freight on above		268
75 HP Brooks Motors	2	290
37 HP motors	2	324
16″ Centrifugal Pump with motor	1	216
Carried forward L.E.		39690

Description	Total	Value
Brought forward L.E. . .		39690
Punchard Skips	6	294
Pile Driving Machines	4	4260
Customs & Freight on above		856
Stone Crusher	1	240
Customs & Freight on above		102
Diving Equipment	1	118
Filter Pump Equipment		2299
Workshop Machinery		1114
Block Moulds	83	867
Accessories for above		221
Diesel Motor «La Meuse»	2	1076
Alternators	3	428
Transformers & Starters	5	735
Air Receiver	1	40
Ashler Skips	20	160
Decauville Diesel locos	1	345
Steel Bulkhead	—	—
Mixer Winget	—	—
Limax Pump	1	27
8" Pump Ganz with Motor	1	114
Grouting Pump	1	110
12" Cenrtifugal Pump	2	767
5" Steam Dinksy Pump	1	10
Air Compressors	2	1022
Semi Rotary Hand Pump	4	8
Hydraulic Testing Pump	1	15
Sets Borings Apparatus	2	100
4T Hand Winches	3	60
Stork Electric Pump	8	192
Diaphragms Pumps	9	90
10T Cranes	1	610
50 HP Motor	1	82
8T Truck B. C.	25	750
Steel Centering Arches	2490	2490
TOTAL L.E.		59743

BEHERA.

Description	Total	Value
Electric Shovel	1	4880
330 HP Diesel & Alternator	—	—
100 HP » » »	1	400
Decauville Waggons	67	570
Parts for Excavation		105
Steam dragline	1	4390
Steam Crane	1	645
Steam Locos 90 cms.	3	1800
» » B.G.	1	1016
Diesel Loco Decauville	1	345
Mixer Winget	1	270
Stork Pump 2 ½"	4	180
Gwynne Pump 3"	1	57
Bernard Pump 3"	1	100
Gwynne Pump 6"	4	580
» » 8"	1	170
Sulzer » 8"	1	68
Caterpillar Power Unit	1	346
90 cms Gauge trucks	77	1020
B.G. Flat Trucks	1	30
90 cms » »	1	23
60 » » »	1	10
Rail bender	1	4
TOTAL L.E.		17009

MATERIALS FOR TEMPORARY WORKS.

ROSETTA.

Description	Total	Value
Rail for B.G.	238	1547
Crossings for B.G.	7	175
» » 90 cms.	38	936
Decauville Track	3600	900
» » crossings	53	438
Sleepers 1.50	4530	698
» 2.60	17719	6850
Sand bags	566400	2460
Steel Buildings	4	2525
Steel Water Tanks	1	55
LOT Fuel Tank	1	40
Timber	8261	8261
Sumps	3	537
Electric Cable	700	700
60 lb Rails & Fishplates	702	5080
W.I. Pipes & Fittings	4494	4494
Flexible Steel Tubing	—	290
Pipes and Accessories for Pumps	—	407
Decauville turntables	32	256
Decauville sleepers, fishplates etc.		814
TOTAL L.E.		37463

MATERIALS FOR TEMPORARY WORKS.

DAMIETTA.

Description	Total	Value
Rails for B.G.	168	1092
Crossings for B.G.	6	156
» 90 cms.	13	316
Decauville Track	3160	790
» Crossings	20	165
Sleepers 1.50	3200	491
» 2.60	15040	5950
Steel Sheet Piling	240	2210
Sand Bags	560200	2503
Steel Buildings	4	2262
Water Tank	1	55
Timber	7804	7804
Sumps	3	537
Electric Cable		520
60 lb Rails & Fishplates	513	3700
W.I. Pipes 40 cms.		1200
Do. 2 3/4 to 10".		1141
Pipe Fittings		102
Flexible steel tubing for pumps		290
Decauville turntables	28	224
12" Steel pipes	200	176
Water tank for bricks	4	220
Siegwart Pipes	10	160
Pitch Pine Timber from our Claim dated 28/10/37	3165	3163
	TOTAL L.E.	35227

MATERIALS FOR TEMPORARY WORKS.

BEHERA.

Description	Total	Value
Concrete Pipes		280
Decauville Track	1300	325
» Rails Single	4510	460
Sleepers	7500	1220
Decauville Switches	8	68
Electric Cable	174	174
16" Dia. Steel Pipes	358	358
Water Tanks	2	110
80, 75, 60, lb Rails	251	1630
B.G. Switches	16	400
90 cms.	1	24
Sleepers Decauville	794	104
Decauville Turntables	4	32
TOTAL L.E.		5785

The price of plant, tools and materials for temporary works provided for the 1st season at the site of works at Delta Barrages amounted to L.E. 250,592. The plant, and tools supplied by the Contractors were not altogether brand new; some of the concrete mixers were very old and out of date, while some of the derricks, pumps cranes etc. were second hand.

MATERIALS.

QUARRIES.

Granite Quarries: A granite quarry (600 m. × 200 m.) in the neighbourhood of Shellal Station and near Aswan was handed over to the Contractors on 26th November 1936. This quarry was chosen jointly by the Under Secretary of State and the Consulting Engineers and a railway siding was constructed by the Egyptian State Railways on behalf of the Government connecting the quarry with Shellal Station for the loading of granite stones. As the work proceeded, a second siding was found necessary to be up to the loading operations. This second siding was also constructed by the Egyptian State Railways on the Contractors and at their cost.

During the first two months the opening up of the granite quarry was very slow, as the sub-contractors to whom quarrying and dressing were sublet were not ready. Much progress was made after the visit of H.M. the King on the 31st of January 1937.

A ceremony was arranged by the sub-contractors, Andrea Viscia, in honour of His Majesty on the occasion of his visit to the quarries, and arrangements were made so that when His Majesty pressed an electric button a huge rock of granite weighing about 500 tons was blasted from the quarry 300 metres away.

On the request of the sub-contractors, they were allowed to quarry granite stones from two quarries other than those alloted to them. One is the vicinity of the Contract quarry and the stones used in the basement of the statue of Late Saad Zaghlul Pacha were quarried in it by the same sub-contractors under another contract. The other is in the neighbourhood of Shellal Station and where from it, stones had been quarried for the second heightening of Aswan Dam. These two quarries had been previously opened up for other works and the sub-contractors were allowed to use them so as to enable them to start supplying the required amount of blockers as quiclky as possible to keep pace with the masonry works of the Barrages.

The work on the original or contract quarry progressed satisfactorily and the contractors were able to supply all the ashler stones for the first season from this quarry.

Blockers.

The dimensions of the blockers are indicated on the contract drawing to be 30 cms × 50 cms for the headers and 60 cms × 30 cms for the stretchers. Limiting the lengths to 30 cms and 60 cms involves some waste in the stones while dressing them. On this pretext the sub-contractors requested to be allowed to use random lengths in the blocker facing of the lock walls and piers. They proposed to use lengths varying from 30 cms to 70 cms with a minimum bond of 15 cms. On their visit to the granite quarries on

the 20th March 1937, Mr. Vaughan - Lee, the Consulting Engineer, and the Resident Engineer discussed this question and decided that headers varying between 25 cms and 35 cms and stretchers varying between 55 cms 65 cms could be accepted.

Orders were given to have the blockers roughly dressed so as to be nearer to a rock face to give a noticeable difference in the masonry between the ashler and the blocker facing.

The average monthly output came up to 500 m3 of ashler and 100 m3 of blockers. This output was in excess of the actual requirements of the first season.

Loading and Unloading of Granites Stones.

Granite stones were transported from the Aswan granite quarries to the Barrage site by the E.S.R. When loading the railway waggons chips or pieces of wood were fixed in between the granite stones to keep them undamaged.

Unloading at the Barrages was carefully carried out with 4 ton cranes. In this way practically all the granite was delivered on site well protected and in good condition.

The number of men employed in the granite quarries were 1483. It is to be noted that the labourers and artisans although of different nationalities carried out their work peacefully and quietly. On one occasion only and for a very short time they went on strike.

The numbers in the different categories were as follows :-

Quarry Masters	7	Station Blacksmith	4
Checkers	6	Egyptian »	35
Assistant Quarry Masters	5	Egyptian Assistant Blacksmith	36
Italian Splitters	21	Boys	102
Egyptian »	175	Men using Dabbura	44
Italian Stonecutters	145	Attala	4
Egyptian »	197	Labourers	170
Sudanese »	56	» cleaning quarries	59
Egyptian Assistant Stonecutters	379	Various jobs	88

Amongst the Egyptian Stonecutters there were some graduates of the Egyptian Government Industrial Schools, who had been nominated as unpaid apprentices by the Contractors. They were put to work on fine dressing work, which work was generally carried out by Italian labourers. The sub-contractors provided them with free accomodation, sanitary arrangement, medical attendance, tools, templates & etc...

PLANT & MATERIALS FOR TEMPORARY WORKS AT ASWAN QUARRIES.

1	Steam Locomotive.
4	Three tons steam cranes.
1	Four tons steam crane.
1	Five tons steam crane.
5	Four tons hand operated fixed steel derricks.
5	Three tons hand operated fixed steel derricks.
1	Four tons hand operated movable gentry steel crane.
1	Three tons hand operated fixed gentry wooden crane.
1	Plate layer Bogie.
1500	m. wide guage lines extended by Contractors.
3100	m. Decauville lines.
17	Decauville flat trucks.
10	Decauville closed trucks.
1	Engine 1.5 HP to operate an artesian pump 2″.
1	» 3 » » » » » » 3″.
1	» 3 » » » » » » 3″.
1	» 3 » » » » dynamo 110—120 volts.
2	Electric Pump installations 2.5 HP 200 V—800A.
1	Lorry Ford 8 cylinder with a water tank 2 m3 capacity.
1	» » 4 » » a » » 2 m3 » .
2	Motor cars 8 cylinders (Ford).

Lighting at Aswan Quarries.

Electric lighting was supplied from a dynamo 110—120 volts turned by means of a 3 HP. Diesel Engine.

Water Supply at Aswan Quarries.

Water is supplied mainly from two sources:

1. From two artesian wells by pumps of 2″ and 3″ dia. each and operated by Diesel engines of 1.5 HP. and 3 HP. respectively.

2. From Aswan Reservoir by means of an electric pumping installation.

As the water level in the Reservoir dropped, water was supplied from the water works of the Aswan town municipality by means of lorries. Finding this insufficient for the quarries, the sub-contractors started constructing a special pipeline connecting a tank constructed at the quarries to a pump installed at Aswan town and which would take water from the pipe line of the municipal water work.

Sub-Contractors Colony at Aswan Quarries.

At the quarries, the sub - contractors built a colony to accomodate their staff, workshops, sheds, stores etc. The buildings are of timber with the exception of 5 houses which are built in rubble stones.

One of the houses of the Aswan Reservoir Government Colony accomodated the Government Inspectors. Checkers lived in a house hired by the Government at Aswan Town.

Ballast and Sand Quarries.

It was intended that sand ballast required for Mohammed Ali Barrages & subsidiary works should be obtained from sites, indicated on plan No. 10, on the western fringe of the desert some 20 kilometres north of the Barrages site.

But it came to the knowledge of the Resident Engineer that there were other areas of the same desert, which might be preferable to those shown on the contract drawings. The Resident Engineer requested the Quarries and Mines Department not to dispose of these areas for the time being, and in the meantime instructed the Contractors to inspect them and to suit their own convenience regarding this question

These quarries were near Birkash Railway Station and about 10 kilometres south of the Government quarries. They are much nearer to the site of the work and moreover the ballast quarries are separated from those of the sand, while they are mixed together in the proposed Government quarries. The ballast is of good quality and good gradation in its natural state, and suits the contract specifications.

For these reasons the Resident Engineer approved of these quarries and approached the Mines Department to hand them over to the Contractors in accordance with their request.

In the vicinity of the quarries three hundred feddans of land, the property of the State Domains, were hired to the Contractors, on which they built their colony, stores, plant and railway lines (See plan No 11.)

Two means of transport were arranged to carry the ballast and sand from the quarries to the site of works namely :-

1. The Egyptian State Railways; a siding was constructed crossing Rayah El-Behera, Muhit Drain and Mansuria Canal by means of three temporary bridges, and connecting with the main line of the Menachi Egyptian State Railway at the Contractors expense. The cost amounted to L.E. 2000.

2: By water way through the Rayah El-Behera and the River Nile. For this purpose they constructed a wharf on the left Bank of Rayah El-Behera, two bridges on Muhit drain, two bridges on Mansuria Canal and two tunnels under the Egyptian State Railway line. They intended to use the haulage system for the transport of

materials from the quarries to the wharf at Rayah el-Behera, but dispensed with this plan and used only decauville line A B and the bridge (C) See plan. The two tunnels were constructed by the Egyptian State Railways on behalf of the Contractors and cost about L.E. 900.

The Contractors requested the Resident Engineer to approve hand screening of the ballast at the quarries, pending the arrival of mechanical screens. Sereval tests were made, and the Resident Engineer gave his approval so long as the right grading was obtained.

The table below shows the mean percentage of the gradation of the ballast quarried in the 1st season as compared with the specified percentage :-

Retained by a Ring	Passed by a Ring	Percentage	
		Contract	Actual
1 ½"	2"	22	20
1"	1 ½"	30	30
½"	1"	30	31
	½"	18	19

For some reason or other, the Contractors were undecided on the method of screening and approached the R.E. in December 1937, asking that they might dispense with mechanical screening and the haulage plant system which they had not then installed at Birkash Quarries.

The R.E. insisted that sufficient quantities of ballast and clean sand, free of impurities and graded in the right proportion as specified by the contract be supplied in proper time to the different sites of the works.

Tests on sand quarried from Birkash Quarries were made and gave satisfactory results.

At their request, the Contractors were allowed to supply a certain amount of sand from a quarry situated at Khatatba on the left bank of the Rayah El-Behera some 40 kilometres north of the Delta Barrages.

The Khatatba sand is similar to that of Birkash, both being desert sand, but the pits from which the former is quarried are very near to the Rayah El-Behera and during the flood period they fill with infiltration water and quarrying ceases. In mixing concrete, it is found out that Birkash sand requires from one or two gallons of water more than that of Khatatba. The reason for this difference will be explained later in the section of laboratory tests.

On the 12th April 1937 when the quantity of ballast quarried amounted to 92600 m3, the Contractors stopped quarrying as this quantity was sufficient for the completion of the first season's work for both the Damietta and Rosetta Locks,

Testing of the grading of ballast and sand was done every now and then on samples taken from heaps stached at the sites of works and also from ballast when being dumped in the hoppers of mixers. This as well as the methods adopted for the washing of the ballast are treated more fully in the section describing the Laboratory work.

In January 1938 quarrying of ballast and sand was recommenced by the Société des Carriére de Katta to whom the quarry work was sublet.

Plant, Tools and Materials for Temporary Works

at Birkash Quarries.

	Quantity
Diara (Sieves)	1225
Saranda (Sieves)	100
Shovels	1020
Pick Axe	1190
Cabbash	92
Fasses	56
Trucks each 0.75 m3 capacity	146
» » 1.00 m3 »	40
Tipping waggons each 5 m3 capacity	41
Flat trucks	9
Platform (flat)	12
Tipping waggons each 0.75 m3 capacity	63
Trolley	1
Water tank 1 m3 capacity	1
Complete power Engine—Tangys R 10 HP	1.
Complete installation of pipes for 7 hand water pumps	1.
Track 60 cms guage (laid)	km 15.
» » » » (in stock)	» 3.5
» 90 » »	» 4.688
Locomotives 10 HP	2.
» 14 »	4.
» 20 »	1.
» 25 »	1.
» 33 »	1.

House Accomodation.

The Contractors provided their staff at Birkash quarries with seven blocks for the accomodation of the staff, canteen office, workshop and stores.

The Government hired a house at Birkash Village at L.E. 50 per annum for the accomodation of the four Government checkers in charge of supervising the work.

Electric Power.

A power house was built for the supply electricity. The power is of 220 volts, 27 amp. and 10 HP.

Drinking Water

Seven hand pump wells were sunk to supply members of Contractors' staff and workmen with drinking water.

Turah Limestone Quarries.

The area defined by the Mines and Quarries Department near Turah Village where stone can be quarried for Mohamed Ali Barrages works was handed over to the Contractors on the 19th December 1936, and quarriyng started on the 5th April 1937. The Contractors were slow in this work. They sub-contracted it to inexperienced people and their attention was frequently drawn to remedy the situation. It happened. as the Resident Engineer had anticipated, that the sub-contractors were unable to fulfil their obligations and the main Contractors warned them this effect. As the works progressed and stones were badly needed, the Contractors, on their request, were allowed to quarry, limestone from a quarry other than that allotted to them, which had not yet been opened. As about 30% of the limestone so supplied was rejected at the Barrage site being of a poor quality, The Contractors attention was drawn to the fact that they must supply stones from the approved quarry in accordance with the Contract. The trouble between the Contractors and their sub-contractors with regard to carrying and transport of limestone continued until December 1937, when they withdrew the work from the sub-contractors and sublet it to Messrs. Doch & Trad.

The total cube of limestone supplied at the Barrages up to the end of January 1938 was 23135 m3.

Ashlar Limestone.

The contract considers (Tabaket Ahgar El-Shawish) stone at Turah quarries to be suitable for the repair and reconditioning of the Tawfiki Head Regulator and the Ancient gateway.

The Contractors, before placing the order on Mr. Andrea Viscia to whom the quarrying and dressing of this stone was sublet, submitted dressed samples of

this limestones for approval. These samples were tested in Mohamed Ali Barrages Laboratory and also in the Chemical Department Laboratory in Cairo and found suitable. Results are shown in the Laboratory section together with a comparison of strength between these stones and those used in the existing structures.

SHEET PILING.

It is suggested under Clause 133 C of the Contract that the sudds shall be constructed generally with a core of mild steel interlocking sheet piling driven well down into the beds of the river, the canals or elsewhere and shall be backed in a substantial manner with suitable materials and shall be similarly protected on the outside to prevent scour.

(And further the Contractors made up their tender on the basis of using sheet piles for constructing the sudds).

This is generally done in practice by driving steel larseen Sheet piles to form the core of the sudd.

But the Contractors before starting the 1st season's work requested the approval of the Resident Engineer to dispense with sheet piling in their sudds where the latter rested on sand, but where the sudds crossed porous materials such as rubble, they proposed to drive sheet piles and put in a gravel filter at the inside toe of the sudd. They believed that they could construct the sudd more rapidly without the use of sheet piles and with slightly more filling the result would be, in their opinion, of equal straunchness.

The following note written by Mr, F.H. Burkitt, their agent, on the omission of sheet piles in sudds was sent to the Resident Engineer.

«So far as the firm can discover, the practice of putting sheet piles in sudds has evolved in Egypt from original tentative attempts to make sudds of insufficient width of sand, for instance during the construction of the original Assiut Barrage.

«If a sudd of sand is given a hydraulic gradient of 1: 7, it will never fail, though there may be sloughing of the downstream toe. The adoption of 1 : 7 is not necessarily advocated as it entails extrapumping and therefore, we have adopted approximately 1: 12.

«Where the sudd rests on sand or clay the insertion of a line of sheet piles in such a sudd has only got any appreciable effect in the near vicinity of the pile. It has little effect at the toe of the sudd.

«The writer has constructed and seen constructed countless sudds of sand on a sand bed without any piles. In not one single instance in India, out of some hundred barrages, has a line of sheet piles been employed, with the single exception of the Lloyd Barrage, where sheet piles had to be employed owing to the impossibility of getting a sudd of sufficient width.

«Where the sudd has to pass over existing subble or similar porous material, a line or lines of sheet piles are an absolute necessity.

In the construction of the sudd by means of suction dredgers, piles of some form (precast concrete piles, wooden ,piles or a few sheet piles) or gravel or stone are required at the nose of the advancing sudd to prevent the carrying away of the material by the velocity of the river; once the sudd is established and the nose protected, the earlier piles can be removed and placed at the advancing nose, this operation being continuously repeated. It is therefore considered useless to drive a continuous line of sheet piles and have all these piles in position where the sudd has been established.

"We therefore request that the Contractors may be permitted, entirely on their rensponsibility of course, to omit the continuous lines of sheet piles previously proposed, except in places where porous material such as rubble is crossed by the sudd. If this request is not granted it will be extremely difficult to start the sudd in time to do any serious work in the river this coming season».

Owing to the variability in the consititution of the soil in the bed of the river and to the enormous amount of suitable materials required to form such sudds and which it was difficult to obtain, the Resident Engineer considered it risky to allow the omission of the sheet piles from the sudds and asked the Contractors to abide by the Contract specifications. The Consulting Engineer on being approached on the question, agreed to the attitude which was taken up by the .Resident Engineer.

The Contractors were disappointed regarding this decision and the following is an extract from a letter received from them on the subject:

«Our disappointment is based on the following reasons:—

1. Our original specifications were based on the Contract being given out at a date much earlier to that on which it was given. There would then have been ample time to bring out all the necessary sheet piling and no difficulties in using it along the whole sudd.

2. As it is, we find it, absolutely impossible to bring out all the sheet piling in time, and, should you insist on your decision it would then be humanly impossible to carry out the first season's programme.

3. This being a temporary sudd, it is of no consequence how we build it provided we undertake that this shall be successfully accomplished, and take on ourselves all the responsibility for its erection in our own way in whatever form that shall satisfy the Ministry.

4. We propose strengthening the sudd so that it shall be perfectly safe, and this at a much higher cost to ourserlves.

5. It is understood that sheet piling will be employed where the sudds cross porous materials.

«We therefore beg you to refer the matter urgently to His Excellency the Minister in order that the Ministry of Public Works shall further examine the question and arrive at a decision that will obviate any delay in the execution of our programme.

The question was then raised to His Excellency the Minister who agreed to the omission of the sheet piling and the Resident Engineer on the instructions of the Ministry communicated to the Contractors the following letter which was prepared in agreement with the Legal Department of the Ministry :

Dear Sirs.

In continuation of my letter of the 14th November 1936 and in reply to your letter dated 22nd November 1936 re your request for the omission of sheet piles in the temporary sudds where they rest on sand, I have the honour to inform you that I have been instructed by the Ministry to communicate to you the following.

In spite of the fact that you have accepted the prolongation of the period during which the tenders were irrevocable without any reserve or conditions relating to the programme of the work and the methods by which it will be executed, the Ministry have reconsidered your request and do not agree in principle thereto. Driving the sheet piles in the main temporary sudds was one of the bases upon which you have formed your tender.

But as the Ministry take great interest in accelerating the work and try their best to remove any obstacle that may arise in the course of the execution of your Contract, and as you mention in your request that it is absolutely impossible to bring out all sheet piling in time and it would be humanly impossible to carry out the first season's programme should the Ministry insist on using sheet piles, the Ministry leave you this season only, under your own risk and peril and without diminishing or effecting in any way your obligations and responsibilities under the Contract both as regards the existing structure or the object to be attained, to construct the sudds in the manner you propose provided that the following precautions should be taken :—

1) The hydraulic gradient in the temporary sudds where there are no sheet piles shall not be less than 1 in 20.

2) The sheet piles to be driven where the sudd runs parallel to the floor of the Damietta Barrage, or any other piles in the said Barrage, will have a penetration not higher than R.L. 2.00 and great care must be taken where this sudd joint the abutment or the flank of the present lock.

3) Such care must also be taken for the downstream part of the said sudd where it rests on any part of the present structure of weir. Driving sheet piles there as is shown in the drawing is preferable.

4 A filter gravel shall be put at the inside toe of the sudds.

5 Enough amount of gravel or rubble stones and sacks filled with sand ready to be used in case of emergency, should be stored on site.

6) Special arrangements should be made to overcome the increased amount of infiltration water.

7) Any other measures of precautions which you will think necessary to ensure the safety of the works, both as regards the existing structure and the object to be attained.

Your attention is drawn to the fact that it is quite probable that there may be cavities underneath the floor downstream the Damietta Barrage where the temporary sudd rests and there will be a possibility of having the floor cracked.

A drawing showing the above mentioned alternations considered to be necessary in your submitted design, is herewith attached.

See Drawings.

The question of omitting the sheet piles was raised again by the Contractors for the Second season's sudd in the Rosetta Branch but they intended to use sheet piles in Damietta, as preliminary calculation made by them showed that the velocity in this branch would be very high and the sheet piling would be essential in the sudd.

Owing to the difficulties experienced in the first season, which will be explained later the Resident Engineer did not agree to omitting the sheet piles in Rosetta.

Later on they proposed omitting the sheet piles from Damietta sudd except in the part parallel to the river and the Resident Engineer refused.

The Consulting Engineer opined that sheet piling in Damietta sudd was essential and in Rosetta, sheet piling would be preferable, but saw no objection to omit it if the Contractors so desired, notwithstanding the difficulties they faced in the 1st season in dealing with infiltration water, and pointed out that this departure from the method of constructing the sudds, as outlined in their tender, would not in any way absolve them from any responsibilities and risks in connection with the Contract.

The case was placed before the Ministry with the request of the Contractors to use the 7.30 ms sheet piles provided for the permanent work of the third season in the temporary sudds. This request was submitted by Contractors with the intention of using sheet piles in Damietta second season's sudd and the Ministry did not agree as the request was contrary to the provisions of the Contract. Also the proposal of the Contractors not to use a sheet piling diaphragm around the Behera site, as herein before mentioned, was put up for consideration.

After several meetings held in the Ministry in the presence of the Government and the Contractors representatives, a solution was arrived at which is self-explanatory in the letter communicated to the Contractors. His Excellency the Minister approved of this solution and the letter was prepared in agreement with the Legal Deparment of the Ministry.

It is to be noted that the Contractors on the instructions of the Ministry had been prevented from unwatering the areas enclosed by the sudds and which had been already closed, until this question was settled.

The following is a copy of the letter addressed to the Contractors settling the question of sheet piles forming the cores of the temporary sudds :—

To:

Messrs. MACDONALD, GIBBS & Co. (Eng.) Ltd

50, Kasr El-Nil Street, Cairo.

Dear Sirs,

Reference to your letter of 26th November 1937, No. 918/33-65 re sheet piles in sudds and your arguments for :-

1) Your view that the design and maintenance of the sudds is the responsibility of the Contactors.

2) Your request that you should be permitted to re-use in the permanent work any undamaged permanent piles which may have been driven in the sudds; I have the honour to inform you that the Ministry have considered your arguments and those of your lawyers Messrs. Perrot, Fanner & Sims Marshall contained in their letter to the Legal Department of this Ministry dated 30th November 1937 and do not agree in principle to them.

Your absolute responsibility for the design and maintenance of sudds does not mean that the Ministry should leave to you the absolute liberty in executing them.

Your tender was accepted on the understanding that steel piles were to be used in the sudds in accordance with plans submitted under paragraph 18 of the Instructions to Persons Tendering, and if required by the Ministry you should drive piles round Behera Regulator and this acceptance forms an integral part of the Contract.

The safety of the existing structure is very important and the Government were quite within their rights under the contract in insisting on piles to minimise any possible risks to the structures, in view of the enormous financial loss to Lower Egypt should anything happen. It is the duty of the Government to protect themselves and the agricultural interests in Lower Egypte

The acceptance of the Ministry for the construction of the sudds without sheet piles last season was for that season only and under your own risk and peril and without diminishing or effecting in any way your obligations and responsibilities under the contract and for you exceptional circumstances which were then existing.

As for your request to be permitted to re-use in the permanent work any undamaged permanent piles which may have been driven in the sudds, I have the honour to refer you, to Arts. 53 A and III of the contract which necessitate that all material to be used shall be new and of the best quality and description of their respective kinds and that the use of materials which have been employed in the temporary works or elsewhere will not be allowed in the permanent work.

But as you have not provided the sheet piles for temporary sudds and work in the due time and as the persistance of the Government on executing the provisions of the Contract and their insisting on executing the temporary sudds and works with sheet piles in the present season may lead to the suspension of works which is not desired by them, the Ministry without in any way affecting or diminishing your responsibilities and obligations or the rights reserved to the Government under the contract agreed to the following.

1) The formation of the core of the temporary sudds for Damietta by steel piles through the whole length. In the portions of the sudds A.B. and C.D. on drawing No. 178 D the penetration of the sheet piles should not be less than one metre in the sand. In the portion B.C. sheet piles of seven metres are sufficient.

2) With regard to the foundation of the Behera Head Regulator it is necessary to drive a ring of steel piling round the site to the required length should your proposal for using another methods be not approved.

3) The Ministry leave you this second season only, under your own risk in any way your obligations and responsibilities under the contract both as regards the existing structures or the object to be attained, to omit sheet piling in Rosetta temporary sudds provided the Resident Engineer sees that the foundations are dried off to the extent necessary.

4) You are allowed to use the permanent cut off piling procured for the third season's work in the temporary works for the second season on condition that they shall be marked and if they will be damaged they are to be rejected by the Resident Engineer (whose decision shall be final and conclusive) and must not be used in the third season as permanent work. A rebate of not less than two pounds per ton of the Schedule Rates for steel piling for all piles driven in the permanent work that have been utilised previously in any temporary works shall be made.

5) The Government reserve their rights in deducting the amounts which will be due to them for the non-use of the sheet piles in Rosetta sudds from any amounts which will be due to you under your Contract.

Please let me have your agreement to the above in the earliest possible time.

I have the honour to be,
Dear Sirs,
Your obedient servants.
(Signed) . . . .

True copy.

The following was received from the Contractors as a reply to the above letter.

MACDONALD, GIBBS & Co. (Engineers) Ltd.

MOHAMMED ALI BARRAGES
DELTA BARRAGE
EGYPT

Ref 1024/RE/33-65

19 December, 1937.

The Resident Engineer,
Mohammed Ali Barrages,
Delta Barrage.

Sir,

We have the honour to acknowledge receipt of your letter No. 11/1/8-719 dated 19 inst., requiring us to accept the solution which have been arrived to after the several meetings which took place in the offices of H.E. the Under Secretary of State and the Legal Adviser of the Ministry.

We accept the said solution and are willing to execute it as set forth in your above-mentioned letter with a reserve that this acceptance should not affect our rights reserved to us under the Contract, as already explained in our letter No. 918/RE/33-65 dated 26th November 1937 and in the letter of our Lawyers to the Legal Department of the Ministry No. F.G. 7708 dated 30th November 1937

However, we specially reserve our rights to claim for any abnormal lengths of piles required in the parts A.B. and C.D. of the Damietta sudd referred to in your above-mentioned letter.

We have the honour to be,
Sir,
Your obedient servants
(Signed) . . . .

The omission of the sheet piles in the core of the temporary sudds resulted in the following:-

Damietta.

Difficulties met with in Damietta lock foundations delayed the progress of the work, and no appreciable amount of work was done beyond the limits of the permanent sheet piles, which had driven in the foundations of the lock; but beyond the effects of springs little resulted from the omission of sheet piles in the Damietta sudds. One spring blew up outside the sheet piling diaphragm upstream of the foundation of the lock and resulted in the development of cracks in the right bank and the old revetment. Had the core of mild steel Larsen sheet piles not been driven in the portion of the sudd parallel to the Barrage, these cracks would have extended upstream and endangered the existing lock and Barrage.

Rosetta.

As a result of the omission of sheet piles in the temporary sudd, infiltration water was excessive and the following difficulties were met with :-

1) As already stated the Contractors failed to establish the catchment drain which was projected to encircle the area of the foundation and consequently a large number of subsidiary pumps had to be erected.

2) Before dewatering the area enclosed by the sudd, a slip occured in the northern part of the sudd.

3) Cracks appeared in other places in the sudd as can be seen in photo No. 27.

4) The area in the vicinity of the downstream block-work apron became water logged and it was practically impossible for the men to walk over it while moving the excavated spoil. Wooden platforms were scattered over the area to help.

5) Excavation to the required levels took a longer time and the Contractors failed during this season to go down to the designed excavation level for the block-work upstream of the concrete floor of the first vent of the Barrage.

6) It can be seen from the table page 37 that the consumption of power used in dewatering at Rosetta amounted to 53% of the total amount.

7) A large amount of earth filling and a larger area was enclosed by the temporary sudd to obtain the hydraulic gradient 1:20 and consequently there was a great distance between the river and the work, so increasing the carry of materials.

Although this state of affairs did not affect the work itself yet the probable effect of any breakdown in the power of pumping arrangements was a constant anxiety to those responsible and to the supervisors. It sheet piles had been driven in the sudd these difficulties would be minimised and the Contractors would have been able to do a greater amount of work.

PERMANENT SHEET PILING.

Two types of sheet piles were used in the works of Mohamed Ali Barrages :

1) Larsen steel sheet piles.

2) Mild steel joist interlocking sheet piles of the Universal type.

The first kind of piles was employed in temporary works to form the cores of the temporary sudds; those used in the southern part of the temporary sudd for Damietta, were 9.00 ms. long and 0.80 ms. wide and weighed 50 kgs. per metre length and those used in the northern part of the sudd, were 8.00 ms long and 0.40

ms. wide and weighed 50 kgs. per metre length. Guide timbers were used to insure that they were correctly driven in a straight line.

If a female pile is driven first, then the groove will be ckocked with mud or sand and great difficulties found in driving the male and on driving the male pile through the groove of the female one, which is already full of sand, the former will tend to force the latter to go deeper than the correct level. The correct method is to drive the male pile first, and then the groove of the female will move easily on the tongue of the male one. This sheet pile has a greater moment of inertia and can stand the pressure of earth etc. better than the Universal kind.

The second type of piles were used in the permanent works, as in the cut-offs, in confining the areas of foundations etc. They are composed of mild steel joists and clutches driven alternately. The weight of the joist was not less than 58.78 kg. per metre run and that of the clutch not less than 23.07 kg. per metre run. The thickness of the webs of the joists was not less than one centimetre.

Considering the method of using the Universal mild steel joist as an orthodox method, the Contractors suggested two other alternatives to replace this kind. The two mentioned alternatives are the Rotinoff concrete piles and the Franki reinforced concrete sheet piles.

THE ROTINOFF PATENT REINFORCED CONCRETE INTERLOCKING SHEET PILES.

The piles are made of 4 to 1 fine granite concrete and are about 60 cms by 30 cms and 7.00 ms. long to the heel. They are reinforced with not less than 192 kgs of steel to the cubic metre (12 lbs per cubic foot) exclusive of the patent locking arrangements. They are grooved at the sides and are driven with steel mandrels inserted in these grooves. The piles are manufactured on site in accordance with designs prepared and furnished by the West's Rotinoff Piling and Construction Company Ltd., of Regent House, Kingsway, London W.C.2.

Special steel bars are also supplied across the pile and allowed to project from each side in a special way as to fit in special groove in a specially designed steel mould. This steel mould is used for interlocking the piles together and is lifted after grouting the space between the piles; the mould should be lifted gradually and slowly as the grouting proceeds. The grouting is done with neat cement by means of a jet which can reach to the bottom, and is applied in the centre of the mould which is hollow. The distance between the piles is usually not more than 1/16" and will not allow the grout to pass freely into waste.

The Frankl Reinforced Sheet Piling.

This system consists of driving steel moulds rectangular in section of dimensions 3'—3" by 6" lengthwise beside each other, thus making a wall of 6" thick. The moulds are hollow and the above mentioned inner dimensions. The inside of the moulds should be cleared of dirt and all other materials before concreting· Steel reinforcement is placed in the mould before concreting. There are four ways to make the bottom of the mould, i.e.

1) To use a green concrete flug (or layer).

2) To use a small thin reinforced concrete slab.

3) To use steel plate 3/32" thick.

4) Cast steel or cast iron shoes.

A base of this sort is supposed to be driven down with the mould itself and left in the bottom after lifting the mould. No concreting is allowed before driving three moulds. Each mould is taken off gradually during the process of concreting.

The contractors, proposal for using one of these two methods instead of the specified method was objected to by the Resident Engineer for the following reasons:—

1) The thickness of the cut-off wall is 0.35 ms in Rotinoff, 0.15 ms in Franki and 0.15 ms in the contract method.

2) The drawback of the bottom design in the Franki method is two fold. First it is not water tight and second the great difficulty in taking off the bottom if for any reason of bad alignment or otherwise the mould had to be drawn and redriven. To rectify this a special designed bottom like that of the simplex system can be used hinged to the bottom of the mould and can be withdrawn with the mould.

3) In the Franki method the vibrations when driving other moulds are liable to affect the pile wall during the setting of the concrete.

4) The main defect in steel Reinforcement in both Rotinoff and Franki's methods is that it is not continuous all through the wall, but breaks at each joint between moulds that is every 1.00 m. in Franki.

5) The operation of taking up the mould in the Franki method makes it very doubtful that the concrete will fill all the voids left in place of the mould even if the concrete is hammered down, an operation which is very hard to perform with the steel reinforcement inside. Moreover, it is not unlikely that earth may enter during the operation of sinking the piles and extracting the moulds.

Also the operation of extracting the mould is not easy, especially as a water jet cannot be used for it will interfere with the concrete.

6) The table below shows comparison between the three different types. The rates given for the second method are only approximate.

System	CONCRETE			MILD STEEL			Total cost.
	Quantity	Rate	Cost	Quantity	Rate	Cost	
	m3	L.E.		m3	L.E.		
Contract Method	14813	2.287	33877.331	5739	11.772	67559.508	101436.839
Franki	2024	25.000	50600.000	154	20.000	3080.000	53680.000
Rotinoff.	4475	23.800	106505.000	780	22.500	17550.000	124055.000

From the above it was found that it was most desirable not to adopt Franki's method to replace the specified way for the construction of the cut-offs. Also for the above mentioned reason the Universal steel sheet piles were preferable to the Rotinoff ones as they were cheaper.

The Contract method was adopted in designing the cut-offs for the Barrages as a safeguard against the corrosion of steel, as when the steel has corroded the concrete between the sheet piles will act. It has been stated that the life of steel does not exceed one hundred years.

The writer would like to mention here, that the iron rails, spikes, and bolts with washers, and the old timber piles, found in the bed of the river, while excavating in Damietta lock foundation, were in very good condition and no signs of rust or deterioration could be traced and not less than 80 years have elapsed since these were placed in the works. This information is enlightening.

Damietta Permanent Steel Sheet Piling.

Pile driving started on the 16th March 1937 and was completed on 18th July 1937. Driving began with one drop hammer machine but two more machines were brought in at a later date and the three worked day and night. Two steam hammers were used for redriving piles to the correct level.

Owing to the sinking of the steam ship Jacobus with 150 Tons of steel sheet piles, the Contractors were short of 56 piles, 7.00 ms long, for Damietta Lock and ten special piles, 7.30 ms long five for Damietta and five for Rosetta, which connect with the cut-offs under the Barrages.

The Contractors being uncertain of the date of the arrival of another Steamer having on board the required sheet piles, requested using piles shorter than those specified in certain places viz, on the land side in Damietta Lock. Also to get the required length they asked to be permitted to use ten welded special piles at the cut-offs in both Rosetta and Damietta Locks. Owing to the fact that the Contractors at that time were for behind their programme for the execution of the works and as any other delay would put them still further behind, their proposals modified so as to comply with the specifications of the Contract were accepted as follows:

1) In the distance of 21.80 m. from the corner piles, welded piles 7 ms. long (formed of two pieces, the lower one 6 metres long and the top 1 metre long) could be used. Rivetted butt joints were accepted and used.

2) Ten welded special piles, each 7.30 ms. long, could be used at the end of the cut-offs of Rosetta Lock. Each pile was formed of two pieces, one of six metres and the other 1.30 ms. long on top.

3) The welded joints in the special piles must be embedded in concrete for a depth not less than 0.60 metres below the joint.

4) All extra excavation and concrete below the levels shown on Contract drawing, which was necessary for carrying out the above, would be at the Contractor's expense.

5) Welding must be done electrically.

The sketch clearly illustrated the above.

The driving of sheet piles was interrupted every now and again by a shortage in piles of certain lengths or the non-delivery of special ones, or owing to break down of the machines. One pile driving machine at Damietta was out of order owing to shortness of its guide piece and it was impossible with this machine to drive the piles to the correct level at on go. This necessitated to have the piles redriven and so time was wasted.

In some instances trouble was experienced in driving the sheet piles, owing either to the clutches and the piles not going down together under hammering, or both the clutch and the piles did not penetrate the stratum easily, and the top of the pile was damaged. The first difficulty in most cases was due to a mistake in the way of driving and the use of a water jet helped to overcome the second difficulty.

The alignment of the sheet piles was exact and in accordance with the contract drawings. The best way in similar works is to have the piles put in between two horizontal guide pieces either of timber or iron which are set in the correct direction, and then start driving the piles by means of drop hammers. The latter in most cases are preferable to steam-hammers.

In very few cases the line of sheet piles gave way slightly when subjected to a big surcharge. The land sheet piles for the east abutment of Damietta Barrages at the corner, where they meet the diaphragm of sheet piles D.S. the subway after being driven in line and to the correct setting out gave way for about 57 cms owing to the very big surcharge coming over it. This was an exceptionally bad case and did not happen elsewhere except at D.S. nose of Rosetta Lock wall. This was due to a very big slip in the bank which was water-logged and to the many springs which appeared at the toe of the bank. Gravel and ballast were dumped over and round the springs at the toe to stop the removal of the substrata. These springs cropped up here and there and if one stopped another opened. The bank cracked and showed signs of slipping but fortunately it happened towards the end of the season.

I presume this was due to the absence of a catchment drain encircling the area. The attention of the Contractors was drawn to this fact on many occasions but they neglected considering it and found themselves in a very tight situation.

After driving the welded and rivetted piles, excavation of the foundations proceeded to the requisite level, as these piles were driven with the longer length at the bottom the Engineer in charge was able, after excavation was finished, to examine the welded and rivetted joints in the piles. In all cases they were found to be in very good condition.

Some modifications regarding driving piles, or redriving piles to have their bottom level lower to insure penetration in reliable sand etc., had to be made due to the silty mud stratum met with as stated under the heading «Excavation». The following includes all such modifications which were carried out:

1.—The line of piles starting from point D for the first two bays was redriven, so that the top level of the piles went down from R.L. 10 to R.L. 8.50, and the toe of the piles went down to R.L. 35.0. See plan.

2.—The continuation of the line of piles mentioned in (1.) for the second two bays were redriven, so that the top level of the piles went down from R.L. 10.00 to R.L. 9.00, and the toe of the piles went down to R.L. 4.00.

3.—Total lengths of piles for a distance of 21.80 ms. near the cut-off recess for the heel post; rivetted butt joint piles were used as Contractors had no suitable lengths ready on site.

4.—Two additional rows of steel sheet piles were driven lengthwise together with nine cross lines to the levels shown on the drawing.

5.—Four additional cross lines were driven across the centre line of Barrage between the subway and the cut-off.

6.—Two lines in the pool downstream the subway, one for confining the area under the land wall, and the other for confining the area under the river wall of the lock.

7.—The total weight of the additional sheet piles was 568 tons of Universal mild steel type.

8.—The total weight of permanent steel sheet piles driven at Damietta was 1054 tons excluding the additional ones.

Rosetta Sheet Piling.

Pile driving at Rosetta started on 11th March 1937 and was terminated on 25/5/37 at the lock and on 18/6/37 in that section of the floor of the Barrage to be finished during this season. At the commencement of the work, one drop hammer machine was used, later there were three of these machines and two steam hammers worked day and night.

Just before concreting the pool downstream the subway, 12 of the eastern piles boxing the lock gave way westwardly for a distance of about .27 m. This was due to the area being heavily water-logged and the piles were subjected to a big pressure, as cranes, boilers and heavy plant derricks etc. were erected close by.

These were put practically right by using ropes and winches and pulling them eastward.

The total weight of sheet piles driven in the first season was 1575 tons.

General Description of Machines and Way of Driving Sheet Piles.

Two kinds of machines were used.

1. The drop Hammer Machine.
2. The Ordinary steam hammer.

1. The Drop Hammer Machine.

The drop hammer machine consists of a mandrel weighing about 2.167 tons The mandrel is attached to a steel rope running over a pulley fixed at the top of an upright frame and allowed to fall freely on the head of the pile. The machine is placed upon a scow. The frame consists of two uprights (leaders) about 15.00 long placed about 60 cms, apart which guide the mandrel while working. The mandrel which is a piece of iron of the above-mentioned weight is provided with grooves in its sides to fit the guides and a staple in the top by means of which it is lifted. The rope used in raising the hammer is wound up round a drum which revolves by means of a steam engine erected on the end of the scow at the back of the leaders. See photo 38.

The rope holding the mandrel is attached to the staple and winding this rope raises the mandrel or hammer to the top of the leader and then the hammer is

dropped by setting free the winding drum by the use of a friction clutch. The advantage of this method is that the hammer can fall from any height, thus securing a light or heavy blow as required. There is also a cap for the piles which weighs about 1.200 tons and can fit two piles & their clutches. This cap is fixed on the top of the piles to receive the blows to prevent damaging the piles.

This machine was used for driving the piles two at a time. Some of the piles were driven first to R.L. 11.00 which was heigher than the required level. To drive these piles to the required level, it was necessary either to lower the machine by excavating under its track or by dollying these piles. The latter was used where the ground if excavated would reach a sort of light and slushy soil and could not stand the weight of the machine. Two kinds of dollies were used, one 4.00 m. long and the other 1.00 m. long. Each dolly consisted of compound section corresponding to two piles with their clutches. Experience showed that dollying piles was not very successful if drop hammers were to be used. The dolly smashed at its top and the piles and clutches were not equally driven and one could not find this out except after the removal of the driving machine and when excavation had taken place. See photo p. 90.

2. The Steam Hammer Pile Driver.

The stroke is about 3 feet and the piston rod weighs about one ton.

The machine rests on the top of the pile and should be kept in a vertical position by two or three guy ropes. When steam is admitted below the piston machine it rises, carrying the striking weight or ram with it, unill it strikes a trip, which cutts off the supply of the steam and the hammer falls under its own weight and also under the pressure of steam applied on top of the ram. At the end of the down stroke, the motion of the ram is automatically revesved, and the strokes repeated. By adjusting the trip-piece, the length of stroke (and thus the force of the blows) can be increased or diminished. The admission and escape of steam to and from the cylinder can also be controlled directly by the attendant, and the number of blows per minute is increased or decreased by regulating the admission of steam.

This machine is very useful and handy in redriving the piles. It is also of great use in driving piles in sand where fast blows are mostly required. When using the steam hammer it is difficult to drive the piles to a correct line and it also requires some effort to keep the machine vertical. In general no difficulties were experienced in driving the steel sheet piles in the works except in one case where a boulder happened to come in the way of one of the piles, but the heavy drop hammer saved the situation and the piles were driven down and this difficulty was overcome.

Although great care may be taken in driving the piles vertical, yet in long lines a small departure out of the vertical along the line (not side ways) in each pile

is unavoidable. This adds at the end of the line. To remedy this tapered piles are inserted whenever the out of vertical distance permits. In case the taper space is narrow at the top and wide at the bottom, then two piles can be used. One pile of a tapered shape having the bottom wider than the top by the difference of the original top and bottom spaces and the other pile of the ordinary type.

While driving piles in sandy ground, a water jet under pressure can be used to help, but care must be taken that the last one or 1.1/2 metres be driven by hammering without any jet so as not to disturb the ground at the toe of the pile.

SURVEY.

A triangulation survey was carried out to ensure the accurate setting out of all the different parts of the works and the survey was complete in itself although it was linked up with the triangulation of the first stage works. A base line about 129.27 metres long was measured along a straight stretch of the existing Rosetta Barrage and a similar base line about 242.90 metres long along the existing Damietta Barrage.

The Survey Department was approached and carried out the work and prepared the attached drawings showing base line, stations etc. etc.

TEMPORARY SUDDS.

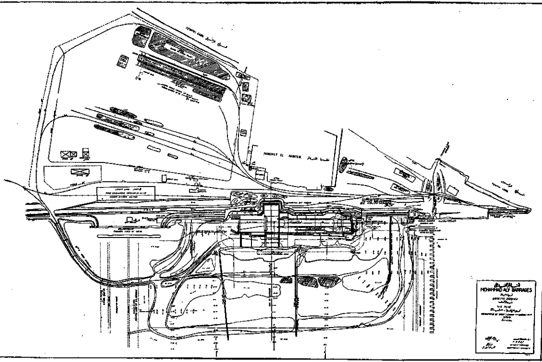
Damietta First Season's Temporary Sudd.

The design of this sudd was based on a hydraulic gradient of not less than one in twenty except in places where steel sheet piles were to be used.

At the inner toe of the embankment, a catchment drain was to be constructed to receive any infiltration water and at a level lower than the excavation level for the floor of the lock.

In the Damietta as well as in Rosetta Sudds the alignment of the sudd was in accordance with the approved plan and benzine tins were used as floats to indicate the line in the river. Work on the sudd started on the 22nd December 1936 Sand bags were first deposited in the river following the alignment to form a skeleton embankment, behind which earth filling was dumped to complete the sudd. Long spurs were made of sand bags to divert the current and avoid erosion in the newly formed embankment. The spoil used in making the sudd was taken from the right bank of Damietta Branch, where it entered into the alignment of the permanent work and from earth excavated in the bed of the river to the foundation level of the floor of the lock and spoil was also brought from Shair Island south of the old Barrage. The Resident Engineer having been informed that the Ministry was carrying out certain training works in the River above the existing Barrage, considered the question of facilitating this work by drawing the attention of the Contractors to a possibly easier and cheaper source of spoil for their temporary sudd. The Contractors on their request were granted this concession which assisted them in speeding up the construction of the temporary sudd.

During the construction of the sudd the discharge through the existing Barrage was confined to vents which were clear of the sudd and this regulation through the old Barrages led to some scouring in the bed of the river upstream and downstream of the Barrage. The scour downstream of the Barrage was soon



MOHAMMAD ALY BARRAGES
MANCHIET EL MANYAL

rectified by changing the regulation to different vents, but the scour upstream of the Barrage caused some anxiety to the irrigation authorities as it was feared that the apprearance of some of the old springs, which had been carefully dealt with in the past, may endanger the present structure.

The sudd embankment crossed the existing downstream weir and was used for the formation of a railway bank for the transport of material from the yard to the site of work. The attention of the Contractors was drawn to the fact that arrangements should be made to protect the core of the permanent weir with two long beams 10" × 10" × 8.00 ms. tied by cross sleepers and so distributed the weight of the trucks on large areas of earth filling.

The existing cracks in the old river wall of the lock weir were carefully watched and readings were recorded daily by means of a special micrometer, reading to 0.005 mm.

Infiltration water was allowed to be discharged freely into the river, as far as evels permitted by means of two pipes 0.20 m. diameter each put in the embankment at the north side of the sudd.

When constructing the sudd the Contractors could not avoid encroaching on the floor of the existing Barrage which was not, however in accordance with the instructions given to them.

The sudd was closed on 24th February 1937 and strengthened with filling rom the enclosed area until the top level reached R.L. 15.50 by the end of July 1937., This work was periodically held up by a shortage in labour.

A core of mild steel Larsen sheet piling 9 ms. long was driven down to reduced level 2.00, with top level at 11.00, on the southern section of the sudd, between the present Delta Barrage and the new Mohammed Aly Barrage. As these piles were not sufficiently long to keep the hydraulic gradient well below the filling of the embankment forming the sudd, a puddle clay core one metre wide was put on the top of the sheet piles and raised 2.50 ms high to reach R.L. 13.00. The top of the Larsen piles was embedded 0.50 m. in the puddled clay core.

Another line of sheet piles was driven in the northern part of the sudd upstream of the weir lock. They were 8.00 ms long and driven down to R.L. 3.00.

This steel sheet piling should have been extracted before the advent of the flood, but the Contractors asked that they may be left in place as they had failed to extract them for want of suitable plant. Experiments were made on a model and on finding that the piles in position would not cause any anxiety or trouble regarding the present structures or navigation the request was agreed to.

In some places the Contractors did not construct the sudd in accordance with the proposed design and the hydraulic gradient at times varied between 1 in 8

and 1 in 10 and infiltration showed itself clearly and slips at the toe of the sudd caused some anxiety. The cube of the sudd as constructed was 52000 m3 as against 64000 m3 in the proposed design and infiltration supplies demanded much pumping.

Rosetta First Season's Sudds.

The design of the sudd was based on the omission of the sheet piling and on having a hudraulic gradient of not less than one in twenty. A catchment drain was also to be constructed in the same way as has been mentioned earlier for Damietta.

Building Rosetta sudd began on 22nd December 1936, and it was closed on 4th February 1937, and reached its top level 14.50 on the same date.

The spoil used in the sudd was excavated from the Rosetta right bank where pitching was to be done.

The river was passed through the eastern vents of the present Rosetta Barrage to facilitate the construction of the sudd, which enclosed the western end of the river, but there was some scouring in the bed of the River, downstream the eastern vents, which caused anxiety to the Government officers in charge of the existing structures, as it was known to them that these vents were originally built on mounds of rubble. It had been recorded that during the construction of the old Rosetta Barrage, scouring took place in the eastern section of the bed of the River to a lower level than that required and to bring it up to the proposed level rubble was dumped in that section of the river and on top of it the floor of the Barrage was laid.

On this account the Government Officers dumped stone to fill the newly formed cavities in the bed of the River before the arrival of the flood.

The omission of sheet piles in the core of the sudd together with a hydraulic gradient less than 1 in 26 as originally proposed increased infiltration water inside the enclosed area formed by the sudd and a great deal pumping was necessary. The sandy bed of the river was disturbed and it became extremely difficult for ths Contractors to construct a catchment drain girdling the works as was originally intended. Springs appreared here and there outside the area enclosed by the permanent sheet piles and the Contractors were unable to construct the upstream blockwork apron which was left for the next season. Much pumping had to be done to complete with the infiltration water in the area enclosed by the two sudds.

The electric power used for this purpose was estimated to be half the total power used for all the works in the two branches of the Nile. And as the Contractors were unable to dig the catchment drain to the required bed level the conditions were not satisfactory.

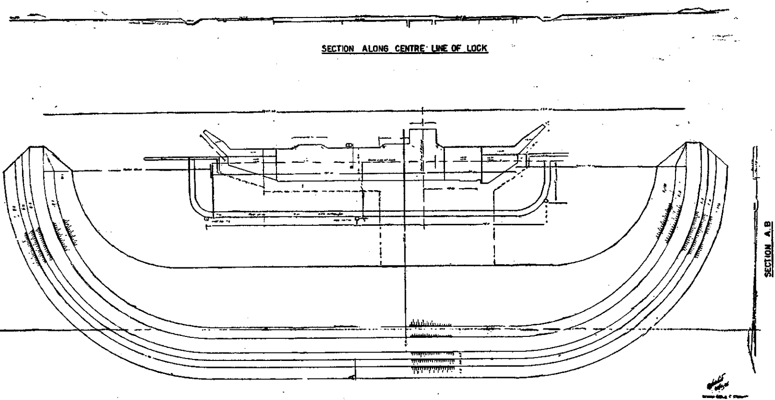
Drawing N°49

MOHAMMAD ALY BARRAGES

PROPOSED PLAN AND SECTIONS OF 1st YEAR'S SUDD — ROSETTA BARRAGE

Revised.

Scale 1 : 500



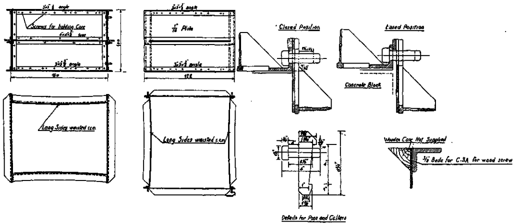
MOHAMMAD ALY BARRAGES

Drawing N° 83 a.v.

N.B. THIS DRAWING CANCELS DRG Nº 80

DETAILS OF M.S. MOULDS FOR CONCRETE BLOCKS

scale 6" & 1" = 1'-0"



DRAWN BY	DATE
CHECKED BY	DATE
MODIFIED BY	DATE

The total amount of earth excavated from the right bank of the Rosetta Branch and transported by native boats and barges to the site of this sudd amounted to 97000 m3, of this 54500 m3 remained in the earth embankment and the balance was washed away by the current, which had been reduced to a minimum by the construction of spurs made of sand bags to divert it away from the newly formed bank, which had been protected at the same time with sand bag revetments.

The total cube of the sudd as designed = 158000 m3.
The cube of the sudd as executed = 54500 m3.

Cutting of the Temporary Sudds.

According to the forecast of the levels of the River the following conditions were expected :

a. Damietta—The level of the River would be kept at R.L. 13.40 till the 29th of July 1937. On the 1st August the level would rise to R.L. 13.80 and then would start rising rapidly from 7.8.37 and the sudd would be expected to be cut on the same day.

b. Rosetta—The level of the River would be kept at R.L. 12.95 till the 3rd August. It then would rise to R.L. 13.70 and then to R.L. 14.08 on the 5th August, and the sudd would be expected to be cut on the same day.

On the above information, the Contractors started taking the necessary measures for cutting the sudds in due time.

On the 30th July 1937, the Contractors began evacuating the site of Rosetta Barrage of plant, tools, stores etc. ane on the 3rd of August pumping was stopped, pumps were removed and the infiltration water was left to rise.

On 4.8.37 at 6 a.m. the infiltratiion water had risen to R.L. 10.30 and after an hour the syphons, that were erected across the sudd on the northern part connecting the main river water to the site, were put into operation and at the time a suction dredger was used to pump water from the main river. At 6 p.m. on the same day the suction dredger was stopped. At noon on the 5th of August, the water inside the sudd reached R.L. 12.90. The water level in the main river was then R.L. 13.56. Two cuts were made in the sudd, one on the U.S. side of the sudd and the other on the D.S. side. In 3½ hours the levels inside and outside the sudd were equalised.

Regarding Damietta, the Contractors started evacuating the site on 1.8.37. On the 5.8.37 at 11 a.m. six cuts were made in the U.S. side of the sudd. Five of these cuts were made opposite the vents of the existing Barrage No. 47—50—54—56 and 59, and one cut opposite the existing lock. The water level in the main river was 13.80 and that inside the sudd was R.L. 13.00. The water levels in the river and inside the sudd were equalised at 1.00 p.m. on the 5th of August when the level was R.L. 14.10.

DEWATERING, SUMPS AND PUMPS.

Damietta.

Three principal sumps were made and formed of cylindrical sleel sections. Each section was 3.00 ms. diameter and four feet high and they were sunk outside the limits of the lock foundations down to the following levels:

Bottom of U.S. sump	R.L. 6.00
» » middle »	R.L. 5.50
» » D.S. »	R.L. 5.00

Sinking these sumps was carried out by excavating inside the steel cylinders with grabs helped by naked divers. The cylinders were weighted with sand bags to help sink them vertically.

The bottoms of the sumps were concreted to prevent sand from being blown up during dewatering.

The catchment drain was connected to these sumps. Dewatering started on 24th February 1937. A gang of men worked continually during the whole season on the main and subsidiary drains to clear them from sand which continued creeping in and filling them up. The amount of dewatering was about 10,000 m3 of water per day.

This could have been reduced to a minimum had the temporary sheet piles driven to form the core of the sudd.

The following electrically operated pumps were erected for dealing with the infiltration water:

U.S.	Sump	.... 14/14" — 8/8"'
Middle	»	.... 16/16" — 14/14" — 8/8"
D.S.	»	.... 10/10" — 8/8" — 6/6"

Subsidiary pumps

Quantity.		
2	pumps	6/6"
1	»	5/5"
2	»	5/5"
2	»	4/4"
1	»	3/4"
2	»	3/3"

These subsidiary pumps were moved from one place to another as requirements demanded.

Rosetta.

Three sumps made of steel cylindercial sections of dia. 3.00 ms and of height 4 ft. each were sunk outside the limits of the foundations of the lock to the following levels :

Bottom	of U.S. sump	R.L. 5.40
»	» middle »	R.L. 4 50
»	» D.S. »	R.L. 4.40

These sumps were fixed in position in the same way as those of Damietta and a layer of ballast was deposited on the bottom to prevent blowing of sand. Dewatering started on the 5th February 1937 and in its first stage was about 40,000 m3 of water per day but later decreased to about 20,000 m3 of water per day.

The Contractors did not excavate the drain intended to catch the infiltration water coming from the river and lead it to the main sumps.

Subsidiary sumps were made at various points and they were equipped with smaller pumps discharging into the main sump.

Pumps were erected at the top of the sump, and the water had to be raised from the bottom a maximum height of 5.50 ms. and then discharged by gravitation into the River. It was thought that by changing the position of the pumps and erecting them at the bottom of the sump may increase their efficiency, but, however ino appreciable difference was noticed.

After the area was partially dried out and the permanent steel sheet piles were driven, the Contractors started to use a system somewhat similar to the «well-point» system to dry the areas and enable them to excavate to the designed foundation level in the dry. The system adopted was not the «well-point» system in its proper sense, and this will be explained later under the heading of «Concreting». Criticism on the same subject and a technical analysis is given later.

The following electrically operated pumps were erected for dealing with the infiltration water.

Main Pumps :

One pump of 12/14" diameter.
One pump of 5/5" diameter.
Two pumps of 7/8" diameter.
Two pumps of 10/12" diameter.
One pump of 8/8" diameter.

Subsidiary Pumps :

Three pumps of 6/6" diameter.
Two pumps of 5/5" diameter.
Four pumps of 4/4" diameter.

Some ot the pumps used in both Damietta and Rosetta works were second hand and frequently out of action sometimes due to their condition and sometimes due to the breakdown of the electric supply, and on these occasions infiltration water rose in the foundations.

This state of affairs was considered to be very serious and the Contractors were forced to instal reserve units driven by petrol engines while concreting.

EXCAVATION.

General.

In general, foundations may be of three types, namely, ordinary foundations on land; foundations below the natural water level, from which the water is excluded during construction; and foundations laid actually under water, or from which the surrounding water has to be kept apart by special contrivances during progress. The foundations of many structures belong to the first category, but are liable to merge into the second when the excavation has to be carried some depth below the surface to reach a sufficiently solid stratum or when the site is close to a river or sea: whilst the chief difficulties are generally encountered in the last class of foundations, which presents the greatest variety of conditions. The stability of foundations depends upon the compactness or tenacity of the strata in relation to the load imposed by the structures erected upon them.

In ordinary foundations, when the soil is soft and yielding as in alluvial formation, bearing piles have often to be resorted to for high and heavy structures; or when for any reason the driving of piles is inexpedient the load can be distributed over a large enough area by an extensive layer of concrete, to enable the soil to bear the weight.

In foundations in water-bearing strata, the water is ordinarily removed, during the construction of the foundations by leading it in trenches or pipes away to a pump, by which it is raised and discharged into a suitable channel. When the water boils up under pressure at a particular spot, it can be controlled by being led into and allowed to rise in a vertical pipe or enclosure, till the height of the column of water in the pipes counterbalances the pressure, or to be kept at a suitable level by means of pumping in a special way such as depositing a layer of gravel some feet in thickness at the bottom of a sump so as not to disturb the neighbouring materials from underneath the surrounding foundation, and as soon as the adjacent foundation is completed, the pipe or enclosure can be closed by concrete and cement grout. Another plan of dealing with water charged with sand, is to surround the site of the foundation by sheet-piling driven down to a firmer stratum, after which the water can be pumped out of the enclosure.

In order to reduce infiltration water it is well to make a trench around the area of any ground that has to be excavated for foundation of big works. A system of drains should then be established running at the lowest levels and a sump located at a convenient spot and a few feet lower; it can then be made the main pumping station of the whole system. To prevent slips and erosion in the drain they may be rough lined with an impervious covering such as clay and the sump should preferably consist of an iron cylinder. In loose earth the pumping station should be at some distance from buildings or roads so as not to affect them. Difficulties often arise in foundations, especially in sand soils, from borings and trial pits made too near to the important parts of the work and they should be made as reasonably distant as convenient. When boring a sand flow may occur and it may be necessary to fill the bore-hole and retain the soil by a covering or by consolidating the sand by means of cement and then perhaps reliable operations may be continued. Borings should be considered unreliable if merely superficial; in any case of importance they should not be trusted but only for the place where they are made, and not as indicating the nature or condition of the soil over a considerable area.

When pits cannot be sunk, it is desirable in a suspectedly treacherous site that the bore holes should be at every 100 or 200 metres.

It is of importance to ascertain the nature of ground to aid discovery of the character of any probable upward rushes of soil; «boils» in foundations are specifically considered. They generally proceed from an impervious top stratum being pierced, thereby tapping the water in a pervious bed which may be imposed upon another impervious layer; the upper bed being excavated removes the weight upon the lower strata and induces a flow of the previously confined water.

In any event immediate action is invaluable when a boil appears. Weighting the ground around a boil with an impervious mass of clay, and the insertion of a stand pipe will indicate the level to which the water will rise and will give an approximate idea of the head supply and pressure. An examination of the colour and nature of the suspended matter in the water and a comparison of it with the strata may show its source, but it is not always reliable unless the same colour is maintained for the lowest depths.

John Newman says in his book «Earthwork Slips» :

The conditions under which «boils» may appear are so numerous that it may be stated they generally occur in any situation when a layer of loose soil has a superimposed bed of more or less impervious soil upon it, which is perforated by the excavation for a lock or other works, and especially should a water-bearing stratum, such as chalk, underlie a sand stratum, also when a water-bearing stratum is superimposed upon sand which lies upon an impervious bed such as clay as water will percolate to the sand, and when sand overlies a water charged stratum, or when sand is below an impervious layer of clay and the latter is tapped.

Great care should be taken not to perforate the firm stratum, as danger will at once ensue should loose soil such as sand be tapped, for cavities will then be produced causing subsidence, probable fracture of the firm stratum «boils» and slips of serious extent».

It is advisable to fill every bore-hole with cement mortar before any excavation is commenced, otherwise they will burst out when the surrounding ground is disturbed. A preferable method is to insert a pipe down the bore, it having been previously cleared of all dirt and to fill it with neat cement mortar, the tube being raised as the hole is filled. In cases of blows a permanent shaft of cylinder is then necessary.

Small springs or «boils» have been sufficiently arrested by depositing clay over them, excavating it, and then putting in the foundations very promptly and before the boil bursts out again. When a boil is tapped it may induce an increased flow of the underground waters, for they find the course of least resistance, and should they reach a fine sand stratum will filter through and set in motion, provided the head if sufficient to overcome the friction, and the support rendered to any overlying stratum will therefore be destroyed.

Excavation for Damietta Foundations.

Excavating in the Damietta right bank at the site of the foundations of the lock started 19th December 1936. Down to R.L. 12 the excavation was in clay mixed with sand.

On April the 5th 1937, a spring, «I» blew up in the foundation area of the lock 5.00 m. upstream the line of piling for the cut off of Damietta Barrage and 8.00 ms. to the east of the western line of piling for the river wall. The water rushed violently from the spring carrying with it decayed blackish materials which had a strong odour. According to the advise of Newman in his book, it was left to flow freely for about 24 hours when the water became very clear and since then this spring supplied drinking water for the labourers and workmen.

The spring was surrounded by sand-bags. The water continued to flow freely and was passed to a main drain by means of an outlet pipe of 0.15 m. diam. through the sand bags.

The materials in suspension in its early stage were examined and found to be decaying matter mixed with sand and silt. Referring to the contract drawings, it was found out that this spring was very near to borings Nos. 5 and 6 which were not scaled after completion. See not extracted from Newman's Book.

In thoroughly investigating the quality of these materials, the conclusion was reached that strata formed of similar materials could not be relied upon as sound

and upon which the foundations of an important work like Mohammed Aly Barrage could be built and necessary measures must be taken to form a firm bed underneath the concrete floor.

The first step taken was to make a sufficient number or borings all over the area.

This being done and plotted on the drawing No. 20 the Resident Engineer took a final decision that he could not in any case, and under no circumstances watsoever, lay the concrete at R.L. 9.00 without ensuring a firm bed, and directed that some of the sheet piles that were already driven to confine the concrete raft of the floor should be redriven to a lower depth till they reached the sand stratum which, with the exception of one place. showed itself at R.L. 6.50.

The Resident Engineer thought of driving timber piles all over the area and excavating one metre lower than the designed level of excavation and then refilling it with sand so as to consolidate the ground. Experience gained from constructing similar foundations of some of the big and important works shows that this method is one of the best which can be adopted.

The only drawback is the lack of time and the absence of timber piles of suitable quality, not on site only, but perhaps in the country.

The Resident Engineer re-examined this question and was of the opinion to confine the floor under the walls of the lock between steel sheet piles. The sheet piles would be driven, to R.L. 4.00, i.e. about 2.30 ms in the reliable stratum of sand and also the piles, that were already driven, were to be redriven to penetrate into the sand stratum; and then after excavating each section of the foundation confined between sheet piles (box) down to R.L. 6.50, i.e. to the good sand stratum by means of sand pumps or otherwise, it would be of refilled with sand deposited in still water to the designed excavation level.

The question was put to Mr. Vaughan-Lee the Consulting Engineer, on his visit to the site, and he agreed to the above and added that it would be advisable also to have cross lines of steel sheet piles driven at intervals, thus dividing the areas into sections or boxes.

This method was possible because the Contractors had fortunately got the required number of steel sheet piles together with a certain number of sand pumps of the site.

Orders were then given to the Contractors to confine the foundations under the walls of the lock between sheet piles parallel to the river side and land side together with two cross lines of sheet piles at intervals. The sheet piles were 6.00 ms in length with the top level at R.L. 9.60. Also the toes of the piles, that were already driven in this area on the river side, had to be redriven to R.L. 4.00.

The photo attached illustrates the above clearly. Excavation in each section thus formed was carried down to R.L. 6.50 and then had to be refilled with sand

deposited in still water to R.L. 9 50, and then the whole area was to be excavated again to R.L. 9.00 the foundation level as specified.

The work was carried out in accordance with the above except for some minor alternations. The same method was adopted in the remaining parts of the whole floor as the nature of the soil was the same throughout the area. A Photograph illustrates this clearly.

When starting to excavate that part adjacent to the Nile Bank heavy timber strutting was necessary to prevent the sheet piles there from collapsing under the heavy surcharge of earth over them. The additional cross-wise sheet piles in this area was essential and temporary timber piles were driven to divide it into small boxes to facilitate excavation. These timber sheet piles as well as the timber strutting were taken away with the exception of the bottom ones as the excavation was finished and filling with clean sand proceeded.

The excavation in the boxes was carried out by hand labour; the silty mud being filled into buckets and deposited in decauville waggons which removed it from the site. Sand pumps were of no avail here. The silty mud was replaced by clean sand brought from heaps and islands in the bed of river near by and deposited in still water.

Old Lime and Homra Concrete Found in the Bed of the River.

While driving the permanent sheet piles for the U.S. land wall (see drawing No. 22.) a mass of old Lime and Homra Concrete foundations was met with in the bed of the River. This mass was built to act as a footing to the old rubble masonry revetment built in mortar. The Contractors suggested partly to demolish it for a depth of one foot and leave the rest and proposed to use explosives or hand labour for the operation. The Resident Engineer, wanting a homogeneous foundation all through, asked the Contractors to remove it and to go down with the excavation till sand was found. No explosives were permitted and hand labour was dispensed with owing to its slow progress and pneumatic drillers were used.

On clearing the site it was found out that this mass of concrete was confined between timber sheet piles in very good condition, and no signs of rust could be traced on the rails, spikes and bolts found in connection with these timber piles. Also the timber sheet piling was not watertight as gaps were found in it. See photo 23. If these piles were driven while constructing the old Barrage they must be about 80 years old and are evidence of the life of similar timber and iron when buried in the bed of the River Nile, and suggest that the impression that one hundred years is the limit requires reconsideration. Drawing No. 24 gives the location of the mass of old concrete and other details and dimensions.

Difficulties were met with while excavating in this part owing to the many springs which blew up violently in several places with water heavily charged with

matter in suspension. They caused much anxiety and delayed the work and were also the main cause of the cracks which appeared in the revetment of the Nile Bank downstream of the old Damietta Lock. The nature of these springs and their effects are dealt with later under the heading of springs.

Excavation in Rosetta Foundations.

Excavation in the foundations of the lock started on 23rd February 1937 and finished on 26th July, 1937. The excavation went down to R.L. 11.00, the top level of the back row of the permanent sheet piling for the land wall of the lock. Driving of the permanent steel sheet piles was then started and, after going down with the piles excavation started again to the foundation level. Subsoil water appeared at R.L. 10.50. Between R.L. 9.00 and R.L. 8.00 excavation was very difficult. At that level the bed of the river was formed of running sand mixed with clay overlying sand of good quality and the whole area boiled. Luckily sand was found at R.L. 8.00, the designed excavation level.

The excavation was arranged to have a slight slope eastwards towards the main sumps, cross drains as well as longitudinal ones were dug leading to the sumps.

All excavation was made by hand: above subsoil water level the spoil was usually carried in baskets: below subsoil water level, the spoil was first shovelled on to timber platforms to give time to the water to drain leaving the sand, which was carried away in baskets in the usual manner; in running silty mud buckets and mortar pans were used.

SPRINGS.

A brief not on springs was written under the heading of excavation with a short account of how some of them had been dealt with. It remains to speak of the nature of the springs both at Rosetta and at Damietta.

Damietta.

At Damietta lock site some of the springs were of a peculiar nature. They blew up suddenly and strongly all over the area except in the area downstream the subway where the surface of the ground was covered with boils. Others appeared in the ordinary way at the toe of the slope of the existing right bank, which caused the bank to crack longitudinally for a considerable distance towards the weir lock.

The first spring No. 1 blew up at 11.00 P.M. on April the 5th, 1937. A full description of this spring was given under the heading of Excavation for Damietta foundations.

This spring continued for 24 hours when it became less vigorous and stopped bringing with it material in suspension and water became very clear. Other minor springs showed themselves between some of the clutches of the steel sheet piles forming the cut offs and running under the subway. These springs closed themselves.

However, most of the important springs appeared in the lime homra concrete area. On 22nd April, 1937 another strong spring blew up through the old lime and homra concrete, in a section where most of the concrete had been removed and where only a layer of about 10 cms still remained to be taken away. The discharge of this spring was big and the colour, the smell and the quality of water rushing through it similar to that of spring No. 1. The water from this spring flooded the whole area of the old concrete and caused delay and trouble in excavation. It was enclosed by sand bags and permitted to flow freely to one of the main sumps.

To dry the old lime and homra area or at least to keep the water level as low as convenient, two pumps of 4" and 6" diameter each were erected on a sump formed in the area by the Contractors. Cracks were observed in the existing revetment of the right Nile Bank between the old Barrage and the new works, and cracks also appeared in the Nile Bank itself, crosswise and longitudinally. They caused some anxiety as they were moving towards the Existing Barrage. A careful examination of the site showed that the sump formerly made by the Contractors to lower the water level in the old lime and homra concrete area had become a very big spring upon which the two pumps were employed day and night.

This increased the flow of the spring and most probably helped in the formation of piping below and caused these cracks to appear. These cracks and the settlement progressed along and across the Right Bank and its revetment in the reach between the old and new Barrages till they reached a point just in line with the temporary Larsen piles already driven and there they ceased.

The Contractor's Agent asked that the works be stopped and postponed till the next season when he would be able to deal with the problem but the request was refused by the Resident Engineer who took control and proceeded with remedia measures.

The pumps were stopped and in this newly formed spring a filter bed was made in the ordinary way by dumping graded ballast and then letting the water rise in an area just large enough to enclose the spring it issued as clear as possible and was allowed to run freely to the main sump.

It should be noticed that this spring apeared before the line of the permanent steel sheet piles had been driven down to the correct level to penetrate into the sand. Once this was done, the water from this spring ceased to flow.

The width of these cracks as well as their vertical movements were recorded daily. Since the sheet piles had been driven to the correct level and the spring ceased

giving water charged with materials from the strata below, no further increase was observed in the width of the cracks or in the subsidence of revetment or bank. This is illustrated by the diagram and the list attached.

As there were cracks in the tower and wing wall of the existing lock of Damietta Barrage, arrangements were made, before that work was ever started and even before dewatering the area enclosed in the temporary sudd was allowed, to measure these cracks by means of a micrometer which read to the nearest .005 mm and the readings were recorded graphically for reference. This instrument measures the vertical, horizontal and lateral movements.

The effect of driving sheet piles in stopping springs and decreasing infiltration water was very apparent on a large scale here, and the Contractor's Agent began to appreciate the full value of sheet piles in similar circumstances. The work now proceeded well and unanticipated programme was finished during the first season.

Rosetta Springs.

The nature of the springs at Rosetta was entirely different from that at Damietta. Except for one small spring, the area was covered with boils when excavation went down to a level of about (R.L. 10,00), this was due to the fact that a water bearing stratum of loany mud is superimposed on a sandy one. Borings showed that between R.L. 10.50 and 9.50 there existed a loany stratum of soil, and between 9.50 and 8.50 a sandy clay one and below 8.50 sand with very little admixture of clay.

When excavation reached the sandy soil the boiling ceased and infiltration water coming from the surrounding cultivated land was lead eastwards to the main sump by sloping the foundation slightly in that direction.

CONCRETE

Concrete has gradually become one of the most important materials of construction at the disposal of the civil engineer on account of its cheapness, the facility with which materials for it are often procured where ordinary building materials are scarce, the ease with which it is manufactured, its adaptabiliiy to various situations, and its good strength and durability when carefully made.

Concrete as used in construction is essentially a mixture of cement mortar with broken stones or gravel or other coarse materials. The mortar serves to fill the voids in the stones and the whole is bound into a solid monolith by the setting and hardening of the cement

In gravel for coarse aggregate, as in sand for mortar, the grading of sizes should be such as to give maximum density. For a given stone, the strongest

concrete will ordinarily be made by that arrangement of sizes which requires the least mortar to completely fill the voids in between the stones, as a surplus of mortar beyond that required for completely filling the voids is an element of weakness in the concrete, as well as a waste of the more expensive materials.

Gravel containing sand is sometimes used without screening by mixing with cement. This is not desirable in practice. As the sand is seldom in proper quantity or uniformly distributed through the gravel, it should be screened out and proportioned properly to the cement and gravel.

In concrete work it is usually necessary to use the materials available in the locality of the work, but where important work is to be done, careful attention should be given to the character of these materials and of the concrete made from them. This is what has been practiced in Mohammed Aly Barrages. Birkash quarries were selected for both ballast and sand, both of which have been experimented upon and cubes of concrete of different proportions tested.

To determine the relative quantities of various sizes of ballast in aggregate it is usual to make a mechanical analysis of the materials. This is made by separating the various sizes by screening and recording the amount retained upon each screen. A special laboratory was established at the works of Mohammed Aly Barrages for this purpose.

Determination of Voids :— The voids in coarse materials, such as gravel, may be obtained by filling a measure of known volume with the materials, and pouring in water until the measure is full.

$$\text{Then the percentage of voids} = \frac{\text{The vol. of water}}{\text{The total volume}} \times 100$$

If the materials were composed of equal cubes, it would be possible to place them side by side so as to leave no voids to be filled by smaller materials. Poured loosely into a measure such cubes would probably show at least 45 % of voids, which would be somewhat modified by shaking down and compacting the mass.

The common method of proportioning concrete is by assuming ratios between the volume of cement, and and coarse aggregate. Cement measured loose may vary considerably in weight for the same volume.

A barrel of cement may measure from 3.5 to 5 feet according to its degree of compactness. It is desirable to follow the recommendation of the Joint Committee on Concrete; one sack (94 lbs.) of cement = 1 cubic feet.

The common proportions are based upon the requirement that the volume of fine aggregate shall be one half that of the coarse aggregate. For materials commonly used this gives a quantity of mortar sufficient to fil compactly the interstices in the coarse aggregate.

In practice, the voids cannot be completely filled, the volumes of the larger materials are increased by the smaller particles lying between them.

Usually a volume of mortar 5 to 10 per cent in excess of the voids most nearly fills the voids without leaving much excess of mortar.

One of the earliest applications of concrete to engineering works was in the form of blocks, where stone was scarce or difficult to dress, and where close-fitting work was required. These blocks are very commonly used in the construction of breakwaters under water, where blocks have to be laid as close together as possible, in a position in which the joints cannot be filled with mortar, Vernon Marcourt in his book on Civil Engineering as applied in construction states that the advantages of this form of concrete are that the blocks being made beforehand and being given ample time to set hard, the work can be conducted rapidly and with certainty as to the condition of the concrete when immersed in water, and that a smaller proportion of cement can be safely used than in concrete work executed under less favourable conditions.

Concrete in mass has been very extensively used in foundations, dock walls, retaining walls, and the portions of break waters above low water, and occasionally for reservoir dams, lighthouse towers, and arched bridges. The reliance, moreover, felt of late years in Portland cement, has led to the use of concrete in mass for breakwaters and other work under water, deposited within framing lined with jute canvas by closed skips with movable bottoms.

The mixing of the concrete deposited in mass has to be very efficiently performed by mixing machines. Concrete-mixing machines consist generally of revolving boxes or cylinders worked by steam-power or electric power, in which the materials are turned over several times, and thoroughly mixed, before being discharged ready for use. The concrete should not, if possible, be deposited from a height, or through a long shoot, for the stones, descending faster than the rest, tend to form a heap by themselves; and the deposited concrete needs mixing again. The greatest care is required in depositing concrete under water to prevent the concrete losing a portion of its cement by falling through the water; and the concrete must not be disturbed when once deposited. Concrete has sometimes been allowed to set partially before being deposited under water, with the view of preventing the washing out of the cement from the concrete in its passage through the water; but it is probable that the concrete loses as much strength by the disturbance of its setting when in what is termed the plastic state, as by the loss of cement under ordinary conditions.

When concrete in mass is deposited in large amounts in successive layers, the top surface of the layer of the previous day's work must be cleaned from any coating of silt before the next layer is commenced; and in the case of concrete out of water, the surface should be moistened, and roughened to ensure the adherence of the succeeding layer.

Concrete in mass possesses several advantages. It furnishes a cheap method for forming broad foundations for heavy structures, and readily fills up hollows or other irregularities in its excavated foundations; and it can easily be finished off to a level surface at the top for the structures to be erected upon it. Moreover though requiring constant care and supervision in its mixing and deposition, concrete in mass can be carried out with very little plant and without skilled labour. This system of construction has been resorted to in dock walls and graving docks from economical considerations.

Dockwalls are constructed of masonry, brickwork, or concrete, or of a combination of concrete with one of the others. Masonry may be employed where suitable stone is easily obtainable and cheap, while brickwork is often used under like conditions, but concrete either in mass or in blockwork has been largely adopted of late years.

In the latter form a type of interlocked blockwork has been used to a large extent in recent works as at Gibraltar, Simons Bay, and Hong-Kong, where basin or wharf walls have been constructed in the sea, without cofferdams, the blockwork being brought up to above the level of low water, and the upper portion of the walls constructed in mass concrete with masonry facing and coping.

Full details about the proportioning of concrete aggregates and also about methods of laying and mixing together with descriptions of mixers etc. are mentioned later under «concreting».

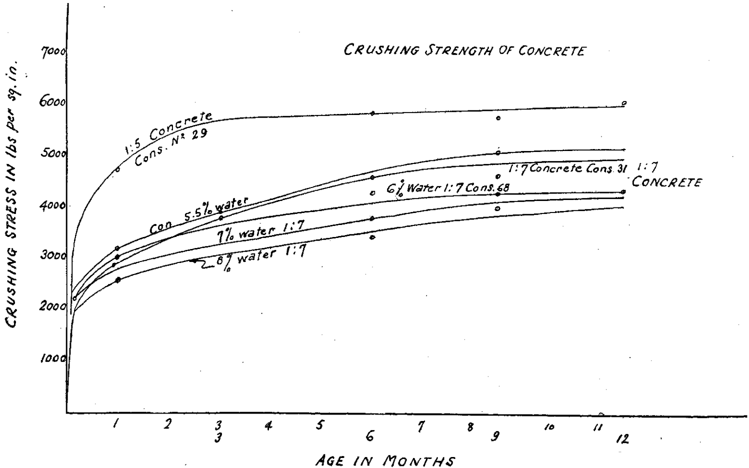
Cubes are made every day from each consignment for testing of crushing strength. The method of moulding the cubes in the field and curing for twenty four hours is identical with that specified in mortar cubes.

The proportion of water is given great care and the water percentage is checked every day more than once. The slump test is used and two inches slump is considered to be very satisfactory and to give a very workable concrete. This makes the percentage of water from seven to eight per cent of the total aggregate by weight. The moisture in the different aggregates is taken into account; the moistened sand and ballast being tested to get the percentage of moisture present.

The slump test is a very simple and very useful test. It should be used extensively to determine the necessary percentage of water to give suitable workability of concrete. It is probable that this test will be the practical basis of the new theories and development in the grading of aggregates for concrete.

Examination of the concrete as it comes from the mixer shows whether it is thoroughly mixed and of proper consistency. Some operators try to speed the work by using more water than necessary and using less time is mixing. This diminishes the strength of the concrete and should not be permitted.

It happens in practice that the mixers for some reason or another stop working for some time and then start again. Concrete may have been deposited and


CRUSHING STRENGTH OF CONCRETE
CRUSHING STRESS IN lbs per sq. in.
7000
6000
5000
4000
3000
2000
1000
1:5 Concrete
Cons. Nº 29
1:7 Concrete Cons. 31
1:7
CONCRETE
6% Water 1:7 Cons. 68
Con 5.5% water
7% water 1:7
8% water 1:7
1
2
3
4
5
7
8
10
11
3
6
9
12
AGE IN MONTHS

the engineer in charge may face the problem whether or not to allow depositing new fresh concrete on the already deposited layer. Laboratory tests have been made regarding this question. Moulds were half filled with fresh concrete and new fresh concrete made at different intervals (one, two and three hours), filled the same moulds. It was found that this combination did not effect the strength of the concrete in compression. If however, the moulds are completed from the same concrete (after remixing) the crushing strength still did not show an appreciable decrease, but the mould showed cracks at joints at about ¼ of the crushing strength. The cube acts like two separate pieces under compression and such concrete cannot be relied upon in shear stresses.

Basalt Concrete

Tests were made on basalt concrete and it was found that it could carry a crushing stress greater than that of the ordinary ballast.

The basalt itself has a crushing stress as high as 1700 kg./cm2 and 1 : 7 concrete has a crushing stress of 167 kg./cm2, while ordinary ballast concrete stress was 145 kg./cm2.

Extension and Contraction of Concrete

This is a matter which needs great care and research. Special instruments were ordered to measure changes in concrete, mortar and cement. The Bauchinger's Apparatus which will be dealt with later was one. The other is the shrinkage testing apparatus designed by Amsler. It consists of three parts :—

1.—The clamping frame.

2.—The screw micrometer.

3.—The comparison bar.

The mould, in which the test piece is moulded, is supplied with two holes in the sides in which two balls can be half inserted. This leaves in the test piece one hole on each side of the prism in which a ball can fit.

The clamping frame serves for pressing tho two steel balls against the centres of the two surfaces of the prism. The screw micrometer measures the variation in the distance between the balls. The pressure (twisting force) on the micrometer is adjusted by means of a special spring and the screw micrometer is not operated directly, but indirectly from a button by the intermediate spring mentioned, so that contact always takes place with the same uniform pressure.

The comparison bar is used as a basis for measurement of the various prisms, whose lengths are compared with the length of this datum bar.

Cement mortar and concrete expand and contract with changes of temperature in the same manner as other materials. They also change in dimension with changes in moisture, expanding when wet and contracting when dry.

The average coefficient of expansion of concrete is about .0000055 per degree F. or .0000099 per degree C. If the coefficient of elasticity of the Concrete is 2,000,000, this would be sufficient to produce a unit stress in concrete of 440 lbs/in2 for a change of temperature of 40° F. if the concrete be restrained from yielding.

Concrete in large masses frequently reaches a high temperature during the period of early hardening due to the heat produced by the chemical changes taking place. Temperature of from 95° F. to 150° F. have been observed.

Daily variations of temperature are not felt at a depth of more than 2 or 3 feet, while seasonal variations may not reach more than ⅓ the amount of the change in the outside air at a depth of 10 feet.

Moisture Changes.

Variation in moisture conditions are of greater importance than those of temperature in causing mortar or concrete to expand and contract. These changes are of special importance during the time the concrete is hardening.

Experiments indicate that concrete kept in dry air during the period of hardening undergoes a progressive shrinkage, while that kept in water expands during the same period, but to a less extent.

In general concrete exposed to dry air may be expected to contract .04 to .06 per cent of its length in six months after mixing, while if kept under water it may expand .01 to .02 per cent. The changes in cement mortar are greater than in concrete, the extent of the change being greater as the mortar is richer.

Tests indicate that concrete at any age expands if changed from wet condition, and contracts if changed from wet to dry. Concrete subject to changes in moisture conditions, therefore, alternately expands and contracts with such changes unless restrained by its position from such motion.

Indications are that concrete, which has been kept wet during the first month or more and then permitted to dry for several months, does not shrink to the same extent as that which is kept dry during the whole period. Concrete kept damp during the early period of hardening should not crack when exposed to the air to the same extent as that continuously dry.

Conraction joints are commonly used to prevent the cracking of concrete by shrinking. The compressive strength of concrete is usually sufficient to take stresses due to expansion without injury to the structure, but tension due to contraction may be sufficient to crack the concrete.

The concrete walls usually need contraction joints 20 to 30 feet apart; in heavy walls they may be 50 or 60 feet apart. The use of light reinforcement in the exposed surfaces between expansion joints may prevent disfiguring surface cracks.

In Rosetta Barrage lock walls these contraction joints have been 35^m and 40^m apart.

Ordinarily these joints may be formed by building the work in sections and allowing one section to set before the adjoining one is placed. This introduces planes of weakness through the work which will yield when the wall contracts.

To bend the ends together, grooves may be left in the sections first constructed and filled in placing the new work. Joints are sometimes made by inserting strips of roofing paper and placing the new concrete against them, or where water tight work is necessary by filling a thin opening in the concrete with asphalt cement having a piece of bent copper inserted in between each of its ends being well fixed in concrete on both sides. See photo.

This subject of expansion and contraction of concrete being of great importance in massive works, the following are extracts from authorities specialised in Concrete Works :—

(1) Very interesting information dealing with temperature, shrinkage, cracks, construction, joints etc, of concrete has been published in the Journal of the Institution of Civil Engineers No. 4 1936 - 37 February 1937 and No. 8 1936 - 37 October 1937 in the paper submitted for discussion on « The Second Stage Developments of the Lochaler Water - Power Scheme » by Arthur Holden Naylor M.Sc. B.Sc. (Eng.), M. Inst. C.E.

The following extracts from the above mentioned paper are of interest regarding the construction of Concrete Works as in the Mohammed Aly Barrages :

« The extent and depth of the raised beach of fine sand and gravel at the east end of Treig dam made it imperative to adopt a design of dam embodying an impervious core - wall which would form a watertight seal up to the crest level + 8190. D. »

« The absence, save in small variable pockets, of clay suitable for a puddle core and impervious filling, and the availability of a large quantity of rubble from the tunnel excavation, were responsible for the choice of a rock - fill type of dam with a concrete core wall keyed into the bed rock.

Concrete Proportion

"The concrete core-wall is of 5-to-1 concrete below ground, except where it is encased in metal sheeting, in which case 7-to-1 concrete was permitted, the aggregate being of 2 inches maximum size."

Contraction Joints

"Above ground-level where there is a possibility of the core-wall becoming de-saturated with consequent shrinkage, vertical contraction joints were provided at

intervals of 35 feet. They were rendered watertight by joggled copper strips and relative deflexion between the adjacent sections of core-wall was prevented by forming a vertical key, tapered and greased to permit shrinkage at the joints."

Temperature Rise

"Electrical resistance thermometers were accordingly inserted near the greatest cross-section of the dam. These and a temperature indicator were supplied by the Cambridge Scientific Instrument Company.

A study of the above revealed many interesting points.

In general the temperature, after rising rapidly, reached a maximum between 36 and 48 hours after placing, after which it fell until shortly after the placing of the succeeding lift when the heat evolved in the latter checked the rate of the loss of the heat and the temperature again began to rise. The concrete was by then blanketed by the superimposed lifts and consequently the rate of dissipation of heat was low, so that generally the rise of temperature continued up to a second maximum which occurred after $1\frac{1}{2}$ to $2\frac{1}{2}$ months. ·Thereafter cooling set in rapidly near the surface and more slowly as the centre of the dam was approached.

"The maximum temperature recorded in 7-to-1 concrete was 111° F. Under adiabatic conditions a temperature of about 123° would have been attained. In the 4-to-1 concrete a maximum temperature of 118° F. was recorded."

"The thermal value of diffusivity is 0.016 C.G.S. units.

Taking the Specific Gravity of Concrete as 2.4 and the specific heat as 0.20, the coefficient of conductivity becomes;—

$$0.016 \times 2.4 \times .20 = .008 \text{ C.G.S. units.}$$

"A normal value of Conductivity is .003 and a maximum value for water saturated concrete is .006

Shrinkage-cracks

"The low water-current and the high density would tend to keep shrinkage down to a minimum, and it would be further discharged by the presence of displacers."

"Cracking must be caused by the setting up of an excessive tensile stress in some parts of the cross section of the dam. Such tensile stress may be due to the restraint of shrinkage which would otherwise take place as a result of cooling and drying-out of the concrete."

"The question of low-heat cement was the subject of study of one of the Research Committees of the Institution, working jointly with the Committee on special cements appointed by the International Commission on Large Dams, and it was to be hoped that in due course a cement more suited to the construction of dams would be obtainable.

Tendency to crack may be reduced by reducing the temperature difference between the heart of the dam and the faces, by increasing the tensile strength at the faces, or by reducing the shrinkage there.

The temperature difference may be reduced by:—

1. Ensuring the dissipation of a greater proportion of the total heat before the concrete is covered by the next lift; this generally involves reducing the rate of concreting.

2. To ensure the more rapid dissipation of heat after placing the succeeding lifts by the circulation of cooling water through pipes embedded in the concrete.

3. To reduce the rate of evolution of heat after the concrete has been covered. With this object a coarse-ground cement with a residue of 7 per cent on the 170-mesh sieve in place of the usual 2 to 3 per cent was used; there is the disadvantage that less heat is dissipated before a lift is covered, leaving more to be dispersed later.

Mr. Stanger found that the concrete strength for the 4-to-1 mix before the change over to the coarse cement was 4,800 lbs. per square inch (about 310 tons/foot^2), whilst after the change over it was 4,650 lbs. per square inch (say 300 tons/foot^2). For the 7-to-1 mix the strengths were about 2,800 lbs. and 2,900 lbs. per square inch respectively for the fine and for the coarse cement; that was equivalent to 182 tons or 189 tons per square foot. Changing to the coarse ground cement had practically no effect on the strength of the concrete which were being used.

4. To use low-heat cement.

   In the case of small masses of concrete there is some value in leaving the timber face-shuttering in place until the temperature at centre has fallen sufficiently low.

5. In the surface of each lift a layer 12 inches deep of large stone displacers, or pre-moulded concrete slabs, has to be inserted, each stone half in and half out of the wet concrete and each jammed up against its neighbour.

6. Instead of displacers, swaged steel hoops can be used, say 3 feet in diameter by 9 inches deep, made of 20 S.W.G. steel the rings could be laid flat and touching one another, half in and half out of the surface of each lift.

Concretes rich in cement, and concretes made with small aggreagates, shrink more than concretes weak in cement and made of large aggregate.

In the records of the Building Research Station (Eng.) there was a considerable number of test results on concrete of a very wide range of water/cement ratio, and for ordinary Portland Cement, it is expected from those results a figure of 300 tons per square foot to be associated with a water/cement ratio of .55, and a figure of 425 tons per square inch to be associated with a ratio of .40.

Dr. Lowe Brown deducted from experiments made on Leggan Dam two facts :—

1. Whatever kind of cement was used hydration took place very rapidly; in lifts of 3 feet 6 inches high it took 1 to 3 days.

2. So long as the upper surface of a lift was left exposed the dissipation of heat was very rapid.

Until these facts had been revealed by the careful records at the Leggan Dam and elsewhere it had been assumed that the heat of hydration took a long time to develop, and that dams should be built in series of isolated vertical sections with gaps between. That practice, which might be called the perpendicular or « skyscraper » method of construction, had been introduced, about 30 years ago. It had been followed in many parts of the world until quite recently, but in view of the results given lately, it appeared to have been wrong and to have tended to increase the temperature--stresses instead of reducing them.

In fact, it would seem that the old English methods of building dams in horizontal layers without any gaps would be preferable, so long as expansion - joints were provided at short intervals—the shorter the better.

Research had already shown that there was one constituent which generated a large amount of heat and added very little to the final strength; the manufactureres would, therefore, doubtless reduce it to a minimum. Most of the other constituents were useful, although they generated heat, some quickly and some showly. Would it be possible to reduce the rise in temperature by some more intensive method of pre-hydration than had yet been tried? The alternative of using pre-cast blocks was the most certain way of reducing temperature - stresses.

Cement evolves from 50 to 65 calories per gram during the first 7 days.

(2) Reinforced Concrete Structures by Hool.

VOL. II

Temperature changes will cause concrete to expand or contract as the temperature is increased or decreased. This expansion or contraction may cause stresses which will be sufficient to cause cracking in the concrete. For example, suppose that a concrete wall 100 ft. long was subjected to a temperature drop of 50° F. The total contraction would be equal to $0.0000065 \times 50 \times 100 \times 12$ or 0.39 inches. If the wall were rigidly held at the ends, this contraction would probably result in one or more cracks in the concrete. However, if the concrete were strong enough to resist this contraction without cracking, the unit tensile stress in the concrete would be $0.0000065 \times 50 \times 2{,}000{,}000$ or 650 lbs/inch^2.

(3) Concrete Engineers Handbook—by Georges A. Hool, S.B. & Nathan C. Johnson M. M.E. p. 252, 253.

Coefficient of Expansion. Mortars and Concretes expand as the temperature is raised and contract as the temperature is lowered. The coefficient of linear expansion per degree Fahrenheit for a series of mortars and crushed stone concrete tested under the writers direction in the laboratories of the College of Civil Engineering Cornell University, in 1916 are listed in the table on this page. All of the specimens were moulded in the shape of bricks 8 in. long, 4 in. wide and 2 in. thick. Heading was done in a specially - constructed resistance type of electric furnace, and distortion was measured by a special extensometer actuated by fused quartz contract bars extending through the furnace walls. Measurements were made to the nearest 0.000,000,9 in per in. of length of the specimen. The test results listed are averages of from two to ten tests of each class of material, the age varying from 1 to 8 months. The range of temperature employed was from about 70° to 212° F. These tests show that the coefficient of expansion of mortars and concretes increases with increase of richness of the mix, but the range of values between a very lean concrete and neat cement is comparatively short. An average concrete will have a temperature coefficient almost exactly equal to that of the average steel. This fact is one of great importance in all classes of reinforced concrete.

Mortars		Concretes	
Mixture	Coefficient of Expansion per 0 F	Mixture	Coeficient of Expansion per 0 F
Neat	0.000,007,83	1:1.1/2:3	0.000,006,77
1 : 1	0.000,007,43	1 : 2 : 4	0.000,006,60
1 : 2	0.000,006,00	1 : 2.1/2 : 5	0.000,005,58
1 : 3	0.000,006,05		
1 : 4	0.000,005,94	1 : 3 : 6	0.000,005,37
1 : 5			

Moisture changes. Mortars and concrete expand in volume if kept wet or immersed in water, and contract if exposed in air.

Experiments made by Prof. A. H. White at the University of Michigan indicate that this property is not confined to the early hardening period but is characteristic of mortars and concretes even after twenty years in service. Another important question which requires discussion is

« Electrolysis in Concrete.»

The following are extracts from authorities regarding this subject:—

Experience and laboratory test have shown that under certain conditions concrete may be seriously damaged by electrolytic action caused by the flow of electric current between the concrete and iron or steel embedded therein.

The phenomena assumes importance under certain conditions of use of reinforced concrete, also the use of concrete foundations and footings in which the bases of columns of buildings, bridges, and elevated railways structures are embedded.

The electrolytic effect differs according to the direction of flow of the current. If electrically positive iron or steel is in contact with concrete, the iron will become corroded provided the concrete is moist or wet and the potential gradient is high enough to heat the junction to a temperature not below about 45° C — (113°F.).

The maximum potential gradient found effective in causing corrosion in moist concrete was about 60 volts per ft. Iron when corroded expands to about 2.2 times its original volume and caused mechanical pressure found in some case to reach values as high as 4700 lbs./inch². This causes cracking of the concrete. The passivity of iron below 45°C is due chiefly to the inhabiting effect of $C_a(OH)^2$ in the concrete , and on this account old concrete in which the $C_a(OH)_2$ has been largely carbonated is probably more susceptible to electrolysis than new concrete in the same moisture condition. For air-dried concrete a much higher potential gradient is required to produce the temperature at which corrosion becomes dangerous than for moist concrete. Under actual conditions, therefore, corrosion from stray currents may be expected only under special or extreme conditions. Normal wet concrete carrying current also increases its resistance a hundredfold in the course of a few weeks, owing partly to the precipitation of $C_a CO_3$ which fills up the pores. This lessens danger or trouble.

Electrolysis of the concrete in contact with negative iron is manifested in a different way. The concrete near the cathode becomes softened, beginning at the cathode surface and extending to a depth of ¼ in. or more. This softening practically completely destroys the bond between iron or steel and concrete.

The danger of electrolysis of reinforced concrete structure through the operation of stray currents has been overestimated. Certain precautions are necessary under special conditions but there is no cause of serious alarm.

Non-reinforced structures are practically immune from injury by electrolysis.

In some instances, injury to concrete containing steel reinforcement has resulted from the leakage of electric current through the mass.

The Joint Committee on concrete in its 1917 report makes the following statements concerning electrolysis :—

The experimental data available on this subject seem to show that while reinforced concrete structures may, under certain conditions, be injured by the flow of electric current in either direction between the reinforcing material and the concrete, such injury is generally to be expected only where voltages are considerably higher than those which usually occur in concrete structures in practice. If the iron be positive, trouble may manifest itself by corrosion of the iron accompanied by cracking of the concrete, and, if the iron be negative, there may be a softening of the concrete

near the surface of the iron, resulting in a destruction of the bond. The former, or anode effect, decreases much more rapidly than the voltage and almost, if not quite disappears at voltages that are most, likely to be encouraged in practice. The cathode effect, on the other hand, takes place even under very low voltage, and is therefore, more important from a practical stand-point than that of the anode.

Structures containing salt or calcium chloride, even in very small quantities, are very much more susceptible to the effects of electric currents than normal concrete, the anode effect progressing much more rapidly in the presence of chlorine, and cathode effect being greatly increased by the presence of an alkali metal.

There is great weight of evidence to show that normal reinforced concrete strutures free from salt are in very little danger under most practical conditions, while non-reinforced concrete structures are practically immune from electrolysis troubles.

CONCRETING.

This subject will be dealt with in the following order and manner.

1—System of drainage and pumping.

2—Well point system and its effect on infiltration water.

3—Methods of laying concrete:

(a) Method suggested by the Contractor.

(b) Method suggested by the R.E. and how it was done.

(c) Mixers and their description.

(d) Washing of ballast. Concrete aggregate.

(e) 1st. layer of concrete and dealing with pottery pipes.

(f) Sumps and how they were made, located and filled.

(g) Grouting etc.

4—Excavation of cut-off and subway and concreting under water.

5—Concrete aggregates, aggregate measures on field, calibration of water ratio tests, etc.

6—Concrete floor at Rosetta & Damietta locks.

7—Concreting walls.

8—Concrete Blocks.

I—System of Drainage & Pumping.

Rosetta.

At R.L. 10.50 the ground at site was full of boils but as the excavation proceeded down to R.L. 8.50 sandy ground appeared and the boils disapeared. The permanent sheet piles had a good effect and helped a great deal in confining and dividing the whole area into parts which were easy to drain; no appreciable springs were met with. Drains embracing the outer lines of permanent sheet piles were dug to lead all the seepage water to the main sumps

The foundation level, when reached, was given a very gentle slope towards the main sumps to help the infiltration water inside the permanent sheet piles to run to special sumps erected for the purpose; these sumps were located under the future walls to prevent any possible blowing up later.

In addition to the pumps used on the main and minor sumps the Contractors tried to apply the well point system as explained hereinafter.

Damietta.

As was stated previously the ground at the foundation level was found to be of very unreliable stratum and many springs were met.

When they were dealt with in accordance with the instructions of the R.E as previously mentioned and clean sand was deposited in the newly divided and confined areas, the result was that the surface area of foundations was practically dry, except for very little infiltration water which was neglegible.

2—Well point System.

This is one of the neatest methods of drying a pit by lowering the ground (subsoil) water level. The principle of this method is that well points are driven down around the area to be dried and are connected by pipes to a pump which is kept in continuous operation.

Drying the area can be carried out by extensive sub — division of pumping and the use of many local rings of well points forming separate cofferdams. Progressive work from one end of the site towards the other gives remarkable flexibility and adaptibility to changing conditions and together with the practice of lowering the ground water in succesive stages by using several tiers of wells as excavation proceeds. This gives marked economy in both plant, cost and pumping cost.

The following is an example of the system of well - points as applied n practice :—

The wells consisted of lengths of 1 ½ inch pipe fitted with well points 30 to 36 inches long wrapped with 60-mesh screen which were jetted down into the sand a intervals of from 3 or 4 feet to as close as 18 inches usually closest in the lower tiers. The top of each well pipe connected through 1 ¼ inch wire covered hose to a 4 inch pumping main, to which were connected one, two, three or four electrically driven pump units of capacity from 75 to 200 gallons per minute discharging by the pipe line to the main sump. Each of these units was mounted on a platform to form a portable unit that could be shifted around by the derrick.

In jetting down a well point a 1¼ inch pipe supplied with water at 40 lbs. pressure was pushed down into the ground and moved around or churned as necessary to loosen up an area large for the well pipe; the well pipe was then dropped into the soft sand loosened by the jet.

When a particular area of the site was to be excavated to a lower level, for example, a ring of points was sunk around the area, at possibly 4 feet spacing, to 5 or 6 feet depth and pumping and excavating were started simultaneously. If these wells did not draw water rapidly enough, or if the ground proved wet in excavating, at a set of points were jetted down between those already in place. If the pumps were not able to hold the vacuum, another pump was put in.

Hose and pipe connection were checked for tighness frequently, this being vital to obtain good results. When the excavation was down to 4 or 5 feet a set of points was jetted in around the bottom of the pit to lower the water level further,

excavation then continuing inside this smaller ring. On the whole, the experience at this site was that the ground water level could be lowered 10 feet in about 4 hours (with 10 to 12 feet of lift and about 30 feet from foot of well to discharge).

The pumpage is fairly represented by the experience with the longest continuous line of wells, whose total length was something over 300 ft. and the pumpage averaged 300 gallons per minute.

From the above it is quite clear that what the Contractors used at Rosetta is not the well point system **in its exact meaning.**

Well-points as applied by the Contractors in Mohammed Aly Barrage, in the upstream box of the foundation lock. Eight pipes of 12" diam. used as caissons were sunk 12 ms. below the level of the foundation. These pipes were perforated in their lower parts. Other pipes, each 6" diam. and 12 ms. in length supplied with a mesh screen at their ends, were put inside the perforated caissons. These vertical pipes were connected at their top, which stood at about 2.00 higher than the foundation level, with the horizontal pipes which, in their turn, were connected to a centrifugal pump 10" diam. The pump was working continuously at full bore discharging 650 ms^3 per hour and was making 1200 revolutions per minute and at a vacuum pressure varying between 12 and 15 atmospheres.

Details of the system are shown on drawing No. 40 together with a diagram showing the mean levels of water in pipes every day from 22nd April 1937 to 20th of May 1937. It was noted that the level of subsoil water (in the pipes) dropped in the first four days from 9.30 to 7.00 and then it went down very slowly in the following 24 days to R.L. 6.30.

The above mentioned levels are those recorded inside the pipes. The pipes were at about 16.00 ms. apart and the line of top levels of subsoil water in between must have taken a shape of more or less a parabolic curve, the apex of which is not known. Most probably the apex had not reached the level of foundations as the box was not dry.

It can be seen from the above that the system was badly applied and the Contractors tried to modify their method in the downstream area. They brought Stork pumps which could be fitted inside the pipes driven down to some 15.00 ms. below excavation level. These pumps were electrically driven. Each pump could make 2850 revolutions per minute and could discharge 15 m^3 per hour, and it could work at a vacuum pressure of thirty atmospheres. The power required for one pump was four horse power. The inside diameter of the suction pipe was three inches and the maximum diameter of the pump where the motor was installed was 22 cms. It is an Austrian make « Ulta ».

After sinking two or three pipes and equipping them with Stork pumps the Contractors abandoned the idea and carried out the dewatering in the ordinary way.

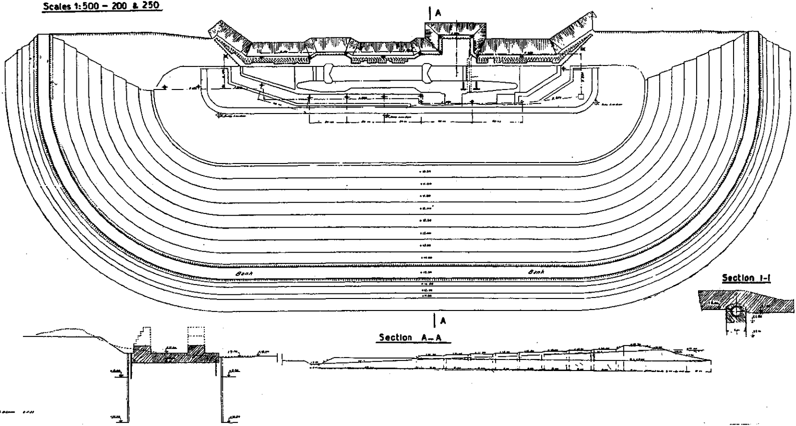
MOHAMMAD ALY BARRAGES. — ROSETTA BARRAGE —

Drawing N° 89

FIRST SEASON

Scales 1:500 - 200 & 250

DEWATERING BY WELLPOINT — PUMPING



The Contractors made use of these small Stork pumps in dewatering sumps or foundations. They proved a failure, because they got of order if any object, however small it was, interfered with their blades.

Before starting applying their system the Contractors made experiments by sinking two wells composed of two perforated pipes of 5" and 10" diam. and of 17 and 15 ms. in length. Inside these outer pipes (or caissons), the Contractor placed other pipes of diam. 3" and 6" and of 5 and 10 ms. length successively and each was supplied at its end with a mesh screen. Each well was equipped with a pump. The original idea of making such an experiment was to ascertain the permeability of the soil underneath. The experiment was wrongly made to give correct results, three wells should have been sunk and then the line (curve) of subsoil water in between the pipes sounded at short intervals and plotted, giving the level of subsoil water at different stages. This, combined with the capacity of pumps would have given a true idea about the permeability of soil. Then according to results obtained the system could have been adapted successfully; the diameters of suction pipes could have been fixed as well as the distance between the wells; the capacity of the pumps required, and the time necessary to dry a pit to a certain depth, known and the whole system properly designed.

The method is mainly based upon the loss of head of water moving through soil. Thus it is essential to determine the factor of permeability of the soil by trial test in the field. As shown before, at least three wells must be used for trial with sounding pipes inserted in between so as to determine the surface curve of the subsoil water, and ascertaining the quantity of water which has to be removed by each pump, the number of wells and their distance apart, the area to be drained and the time needed for drainage.

Centrifugal pumps are usually used with a suction head of about 8.50 ms If more depth is required then turbine pumps must be used. To reduce the suction head the operation can be made in steps. Another way to help is to make the outside meshed pipe air tight from the top to where the suction pipe is lead to the pump. The outside pipe i.e. the well pipe should be perforated only in the part below the required lowest level of subsoil water. The well pipe being thus air tight all through help partial vacuum to occur in its upper parts.

3—Methods of Laying Concrete.

(a) Method suggested by the Contractors:

The Contractors submitted a plan showing their proposals regarding the laying of the concrete of the floor of the Rosetta Barrages. Three mixers were to be erected on the Nile Bank with a decauville line below it on a step in the bank. Mixers were to empty their contents into decauville trucks which could be carried over by means of derricks and to be emptied in turn in the places to be concreted. Three derricks were proposed for this service. The railway track of these derricks

would be constructed on the site of the concreting. Drawing No. 42 shows details of the scheme including ballast and sand stacks, washing troughs, etc. etc.

They divided the area to be concreted into strips, each five metres wide, which would be concreted alternately.

The Resident Engineer criticised this method of laying concrete as it was liable to hinder the surface drainage and preferred that concreting should start from one end of the site and proceed towards the other, enabling the infiltration water to run freely to one or more sumps.

Furthermore two derricks only out of three could worked at one time and the output of concrete per day would not be enough to meet their progress diagram, as one derrick makes 100 shifts each eight hours and each movement will deposit one skip of $\frac{3}{4}$ m^3 of concrete, making a total of 75 m^3 of concrete every 8 hours. Also the tracks of the derricks would be constructed on the concrete raft of the floor and great care must be exercised for the safety of the newly deposited concrete.

(b) Method Suggested by the Resident Engineer.

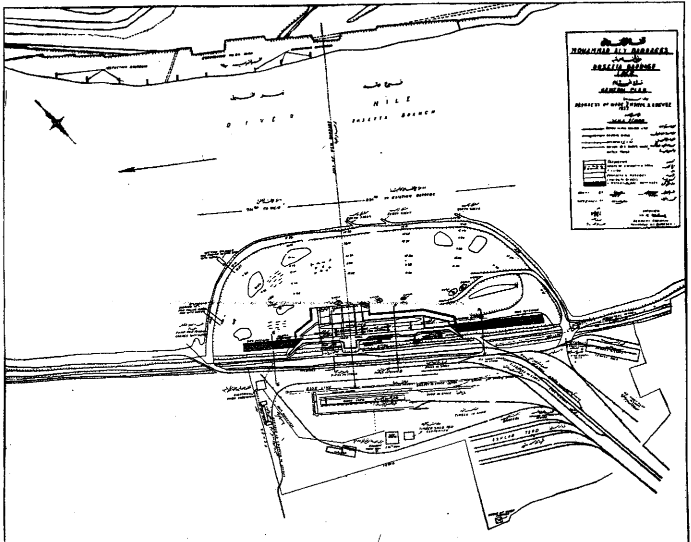
The Resident Engineer suggested the following method :—

Six mixers or more would be erected inside the dried area encircled by the temporary sudd. Ballast and sand would be stacked in the space between the mixers and the main embankment of the sudd which was more than ample; troughs for washing ballast would be made near by and connected to the drains leading to sumps and railway tracks connect the places of stacking ballast, sand and cement to the main yards.

The concrete would be carried in decauville tracks (half cubic metre capacity) running on decauville railway lines. Care should be taken to place the mixers sufficiently far from the site to be concreted so as to allow for a reasonable slope for the deeauville line connecting the mixers with the area. The floor, being concreted in three layers each one metre thick, would need to have the decauville line raised one metre on small rectangular concrete pillars specially made every time concreting started for one of the layers. Two decauville lines would run over the area to be concreted. One for the full trucks and the other for the empties. These lines would be carried on heavy longitudinal timber beams ($0.20 \times 0.20 \times 8.00$ ms. approximately.) supported on cross timber beams of practically the same dimensions and these latter beams spanned the timber shutterings which were used temporarily in laying the concrete. Generally the distance between every two shutterings was to be 5.00 m.

It must be noted that these shutterings should be constructed sufficiently strong to withstand the pressure of the concrete while it is being deposited.

The supports of the timber beams were located outside the area to be concreted.


MOHAMMAD ALY BARRAGES
GENERAL PLAN
RIVER
NILE
ROSETTA BRANCH
BASE LINE

This being more handy and more rapid was finally adopted and proved successful.

(c) Mixers and their Description.

At the beginning of work the Contractors started with six mixers which were increased later to eight on each of Damietta and Rosetta Barrages. The majority of these mixers were of the Ransom and Rapier make and of the drum mixer type and were electrically driven and the operation of mixing being occomplished by putting the aggregate mixed with cement into the hopper fixed on the top of the machine. The hopper is opened and mixture is mixed thoroughly by means of blades and scoops attached to the inside of the mixer drum. Materials were charged into the drum by means of the hopper attached to the vertical side of the drum and provided with a flap door. The discharge of the materials from the drum was made by inserting a trough into the opposite side of the drum in sueh position as to catch the concrete as it was poured from the mixing buckets. The machine was provided on the top with a water tank with a gauge attached to it so that the quantity of water could be easily adjusted.

To have the mixture well mixed the machine had to make 18 revolutions per minute. The process of mixing one batch had to take at least four minutes to be complete and ready to be deposited on site. The capacity of one machine was 0.75 m^3.

A small number of the machines were Carton make and of the pot type. The pot is of a special shape and composed of two portions, each of which is a part of a cone. The two parts are fitted together and the pot arranged to rotate around itself and move vertically up and down when wanted. The materials were charged into the pot by means of a movable hopper placed at the bottom and which was lifted mechanically to the top; and to discharge the concrete after mixing, the pot was rotated vertically to pour its contents to a decauville truck. The pot was provided with blades and scoops inside to mix the concrete. These blades were not long enough to ensure good mixing in a reasonable time.

The machine was electrically driven and was equipped with a water tank at the top for the supply of water to the mixture in the machine.

(d) Concrete Aggreagate and Washing of Ballast.

Proportion of concrete aggregates are fixed in the contract specifications and care was taken to check them continuously. Grading of ballast, sand fineness and quality were also checked daily and the cement was tested in each consignment. Tests were also made on concrete when being deposited on site, where the measures for all aggregates were fixed and checked. The percentage of water ratio for concrete was given great care. All such details are given under the Laboratory Section.

Washing of ballast was done on the site twice before mixing. For this purpose a decauville truck was drilled with holes on both sides and at the bottom, and equipped inside with an iron grid at a small distance above the bottom of the truck and while the truck was being filled with the ballast, the first washing was done by having water under pressure sluiced on the ballast. The ballast was then removed and dumped on a wooden platform and the second washing made. The wooden platforms were raised a few centimetres above ground level to allow water to drain through holes pierced in the wood taking with it any dirt. Further explanations are given later.

(e) First Layer of Concrete and Pottery Pipes

The final ground level of the foundation was given a very gentle slope towards the main sumps as mentioned earlier.

Concreting started for the floor of the lock cross wise, i.e. from the land wall to the river wall, in strips 5.00 wide each.

To get rid of the infiltration water while laying concrete, pottery pipes of 8" daim. were used. The pipes were laid down a few centimetres below the level of the excavation and to the sumps made to receive this water, and were given a gentle slope steeper than that of the ground. All lines of pottery pipes in one pool were lead to a specially made sump upon which pumps were erected. Vertical iron pipes from 2" to 8" diam. were put on top of the pottery pipes and spaced about five metres apart. Special arrangements were made to ensure a good way without any hinderance for grout between the steel and pottery pipes.

The concrete in the first layer was of ordinary consistency and the ratio of water given was about eight per cent of the total volume, so no efforts were made to use dry or semi dry mixture in places where water prevailed, but care was taken first to get rid of all the water if possible and then concrete started practically on the dry. Sketch of a line of pottery pipes and how the vertical iron pipes are connected with same is shown on drawing.

(f) Sumps

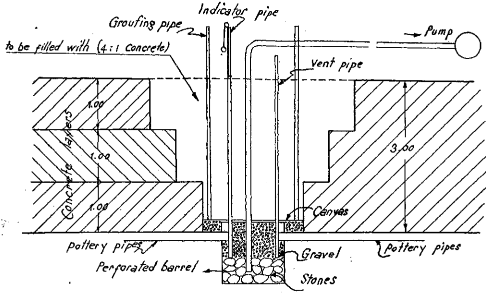
Sumps were always located in places which come under walls; so that after treating the sump in the ordinary way, the weight of the wall coming on the top of the sump prevents any bursting.

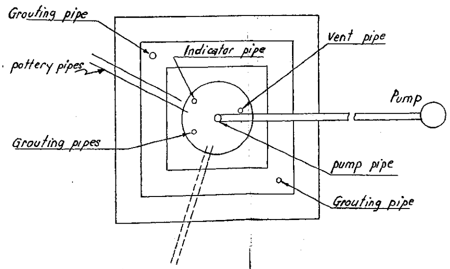
The sumps were made to receive the drainage water from the different lines of pottery pipes and usually consisted of an ordinary oil barrel, well cleaned by firing the inside before use and of about 1.50 diam. and 0.70 m. in height and provided with opening to receive the pottery pipes from many directions.

Pumps were so erected on the sumps with their suction pipes deep in the sumps so as to keep the water level below the excavation level. Round the barrel the first layer of the concrete was deposited and the second layer was stepped back.

TYPE OF A SUMP

Scale 1/50





NOTE Concrete used for filling the sump is 4:1

Concreting the sumps generally started after depositing the second layer of concrete and the pump was kept working during the process, as it is of great importance to keep the level of the water in the sump constant and at a lower level than that of the concrete deposited. Two pumps with two suction pipes were always used, so as to have a spare pump if one happened to break down and a vent pipe was provided in the sump. The bottom level of the suction pipes was below the level of excavation level and granite chips were laid around them together with the vent pipe. The bottom level of the vent pipe was at excavation level. Clean ballast was laid on the top of the granite chips in the barrel to a level higher than that of the excavation level and covered with clean sacks, 4 : 1 concrete was then deposited in the sump. The pump was kept working for a period of twenty four hours and then taken away, and the suction pipes were then left to be used for grouting.

(g) Grouting.

Cement Grout used was of the ratio 1 : 3. The mixture was kept continually disturbed while grouting was carried out by means of double force pumps. Each pool or in other words every strip of the floor was grouted separately starting from the grouting pipes which were furthest from a sump. The pressure exerted by the pumps for working the grout began low and then increased up to twenty or thirty pounds per sq. inch. In grouting, the age of the concrete, as well as its thickness, had to be considered carefully.

The machines used in grouting were very simple. The mixture of water and cement 3 : 1 was put in circular tanks, each about 0.70 m. diam., and equipped with a mechanism by means of which a fan, put at the bottom of the tank, could be rotated by hand.

The pumps used were double force pumps which were capable of making a pressure of about 100 lbs/in^2 and were operated by hand. The photo attached shows the way adopted and the plant used.

In one case at Damietta the subsoil water rose from the grouting pipes to a height of about two metres above the top of the second layer of the concrete of the floor.

To deal with this, the grouting pipes were lengthened by adding to each of them a length of pipe not less than three metres in order to put the water under a static head. Grouting then proceeded in the ordinary way. Plans No 48 showing the grouting pipes, their number and the order in which these were grouted, is attached.

4. Cut-Offs

Excavation started in the cut-offs in July 1937 at Rosetta and at Damietta. Different methods were adopted. A trial was made with sand pumps; the soil being sandy, jets of water under pressure were directed on to it to stir it up and allow the

pumps to take off the water charged with sand, but the sand did not stay well suspended and the sand pumps were not efficient with the result that excavation was delayed.

Naked divers were then called in to do the work. Special wooden trestles were erected on top of the cut-off supporting wooden drums to which were attached ropes tied to specially designed buckets. The divers, taking the buckets in their arms, dived into the trench and filled them with sand from the bottom. A couple of minutes were usually enough for the diver to fill a bucket and return to the surface of the water. The buckets are of special design having sharp edges to make it easy to cut into the sand. The details of this system are shown in the photograph.

The system was successful but expensive and the Contractors sought another method for excavation. Grab excavators could not be easily used, as the distance between the sheet piles was only 1.50 ms. and the grab is about 2 m.

As the contractors had no efficient sand pumps they tried to replace them emporarily by a pulsometer, which was successful in the Damietta cut-off. Steam from the boiler for the pulsometer was used to stir the sand in the bed of the pit. It was understood that the Contractors would take necessary measures to supply good and efficient sand pumps for this work next season.

5. Concreting of Cut-Offs

The width of the cut-off between the sheet piles was 1.50 ms. and was heavily strutted with timber to avoid any collapse of the piles.

The specifications of the Contract stated «that concrete of cut-offs should be deposited through water by means of special underwater skips handled by a portable steam or electric crane. When once a section of the concreting has been commenced it shall be continued without cessation until it has been completed for the full length and height. The cut-off shall be divided into sections by means of steel bulkhead shutters. A key shall be formed between each section by means of tapered core 0.50 m. by 0.30 m. attached to the back of the mentioned shutters».

The cut-off under the lock, being 30.50 ms. in length, was concreted in two lifts; the first one was made one metre thick and was deposited under water and was left to set. After 48 hours the trench was pumped dry and the top of the first layer was cleaned, picked, etc. and then the second layer was deposited to the full thickness

This system was successful. In two places water appeared through the concrete somewhat like weak springs and was dealt with carefully and satisfactorily by filling with neat cement, directly on top of which concrete was deposited.

Experience showed that the one metre thick formation of the first lift deposited under water was not thick enough to counterbalance the upward pressure of the

subsoil water when the pit was pumped dry. One feared that the concrete might blow but happily nothing happened as the second lift was deposited as quickly as possible. The time factor was very important here. Also « laitance » appeared on top of the first layer when water was pumped out, but was cleared away before the second lift was deposited.

Skips with movable bottoms of the usual form were first used but as they were too big for the width of the cut-off between the sheet piles, they were replaced by specially made cylindrical skips of 0.50 m^3. capacity.

The latter were about 0.50 diam. and 2.00 m. in height and provided with a movable door at the bottom which opened outwards from the centre, and they were also equipped with doors at the top to protect the concrete from being washed when lowered below water. When working the skips were lowered as deep as possible to avoid the concrete being dropped through a big height under water.

A modified Trimmy's system was used in Damietta.

6. Concrete Floor for Locks.

Rosetta Lock Floor.

Concreting started on 26th of April 1937 with six mixers, four of which were of the Ransome's types and two of the Carton type. The output of each mixer was about 80 ms^3 for a full day's work of twelve hours. Concreting the floor was finished on the beginning of July 1937, together with the floor of the 1st. vent of the Barrage but excluding the slope between the high level floor and the low level floor D.S. the subway which was done on 27th July 1937.

A recess 30 cms. deep was left in the low level floor to receive the toe of the slope, i.e. the thickness of floor in the area of the recess was 1.70 ms. When cleaning the recess before depositing concrete in the slope a hair crack, 7.00 ms. D.S. the centre line of the subway, was observed across the floor and just upstream an expansion joint which was made in the lock walls. Very little clear water appeared from five holes of about one millimetre diam. each. It was doubtful if the crack in the floor continued under the walls and it was probably due to contraction at the change of floor sections.

However, the crack was not considered serious and remedial provisions were taken by extending the high level floor, of level 11.00, nine metres further downstream the centre line of the subway. Tie bars were put across the crack at R.L. (10.50) and grouting was effected.

The cube of cement used in grouting this crack was .93 m^3. The volume of the piping used in the grouting operation was .85 m^3. The difference was .085 m^3 most of which was probably lost during the process of grouting. This shows that the crack is insignificant. See sketch.

Mr. Vaughan-Lee agreed to these provisions. He advised putting a layer of sand one metre thick on the floor next season when the lock will be dewatered for the erection of the gates, etc.

Damietta Lock Floor.

Concreting started on 6th June 1937 for the floor raft of the lock with four mixers (Ransome). Progress was hampered and irregular as unsuitable material had to be removed from various places in the bed of the river and refilled with sand before concrete could be thrown. However, the concreting of the floor was finished on the 31st July 1937 with the exception of an area of about 380 m^2 in the third lift upstream the subway. Care was taken in all works to have the tops of the steel sheet piles well embedded in the concrete to avoid seepage from below the deposited concrete next season, when the Barrage foundation will be laid; there was no time during this season to throw concrete in the floor of the Barrage.

Soonafter the concrete had been laid in a small portion downstream the subway starting from the land sheet piles, and when it was still green, cracks appeared. This was due to several boils occuring outside the area being concreted and in the vicinity of the wooden posts used in strutting the timber shuttering confining the deposited concrete. This resulted in weakening the power of strutting the shuttering and causing the latter to give way while the concrete was still green.

The Resident Engineer ordered this concrete to be demolished and taken away and new lines of permanent sheet piles to be driven lengthwise dividing the area into three different strips. The unsuitable material was removed and replaced by clean sand tipped in still clean water to the required level as mentioned before and the concrete then laid in proper condition and no signs of failure were traced.

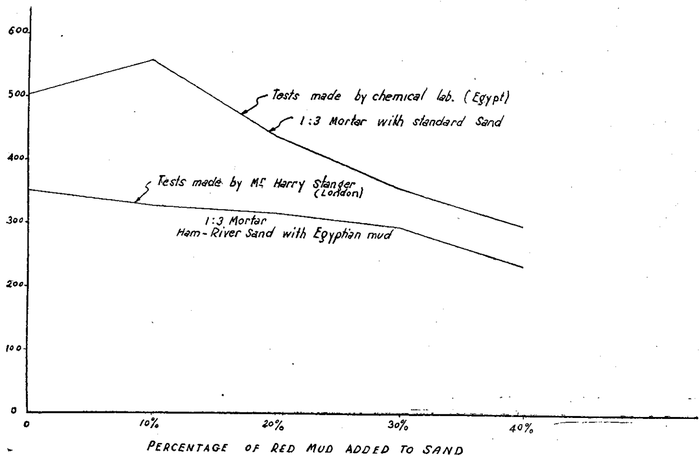
Also the concrete below the subway tubes was condemned and removed owing to the cavities discovered underneath, which were caused through pumping from a sump left in the pit. This sump was formed at one end of the pit and a pump was erected on it. The idea was to keep the level of the infiltration water constant till the next day. The pump continued working without necessary precautions being taken to prevent sand being removed from underneath the concrete already laid in the neighbourhood and no gravel etc. was placed to form a filter bed at the bottom of the sump. Pumping the sump dry resulted in piping underneath the concrete and led to the formation of cavities.

7. Concreting Walls.

Rosetta.

The method of transporting concrete by means of trucks running on decauville lines adopted in concreting the floor foundations was also employed in concreting the hearting of the walls. In some places steam cranes were used to facilitate the

EFFECT OF MUD ON TENSILE STRENGTH



the process. The decauville lines were supported on wooden beams resting on concrete supports or pillars, which were cast to special shape and supplied with suitable keys horizontally and vertically as they would form part of the wall itself and more cement was added, than the ordinary proportions, to make the mixture richer. Concrete was deposited in layers one metre thick and the facing of the walls was built in granite blockers as specified. Three courses of the blockers were first build and left for twenty four hours for the mortar to set, then followed the concreting of the heart.

A battery of mixers was erected on a specially formed berm in the right Bank of the River facing the lock walls and special skips were used for the transport of concrete. Derricks, which were located on the top of the bank, worked continually lifting these skips and depositing the concrete in the area to be concreted.

8. Concrete Blocks.

Blocks Yards.

A block yard was arranged for each of the two Barrages in which to mould the concrete blocks which were to be placed on the U.S. & D.S. concrete aprons of the Barrages. Each yard was about 7.00 ms. wide and 130 ms. long; the length was found to be insufficient and later increased to 190 ms. The floors of the yards were made of 8 : 1 concrete 15 cms. thick and the surface was made to slope gently towards a small drain that ran lengthwise collecting all surplus water.

Construction of the Rosetta yard began on 17.3.37 and was completed on 1.4.37; that of Damietta started in February, 1937 and ended in March, 1937.

Each of the two yards was equipped with a heavy electrically driven gantry travelling on a railway track laid on both sides of the yard, to move the blocks from one place to the other. The gantry consisted of a warren girder bridge of 23.00 ms. span, supported on four steel trestles, two on each side of the yard. It took about one month to erect the gantry. Making concrete blocks started on 26.4.37 at both Rosetta and Damietta.

Special steel moulds for making the blocks were made in England of dimensions 1.50 × 1.25 × 1.00 ms. which differed from the specification — 1.50 × 1.22 × 1.00 ms. The delivered moulds were accepted and others were made locally in Cairo of steel plate 3/16" thick.

In the longer sides of the moulds the plates were waisted one centimeter. All the plates were stiffened with steel angles to prevent them bulging and the edges of the blocks were chamferred by fixing a special piece of wood at the edges of the moulds. A recess for a two headed lifting bar to be used in raising the blocks was left in the centre of each mould by a special tapered piece of timber.

The concrete for the moulds was mixed in a Ransome Mixer, identical with those used in concreting the floor with the exception that the charging hopper was

movable and could be lifted or lowered as was necessary. It was erected on one side of the yard and when the mixture was ready to be discharged it was dumped in a special separate hopper, which could be moved across the yard on a beam bridge supported on the mixers frame on the side and a support on the other side of the floor of the yard. The whole apparatus was electrically operated. To obviate the under side of the blocks sticking to the floor during manufacture ordinary paper was spread below the mould in which the block was made.

Owing to a late start, the contractors were unable to complete sufficien matured blocks (in accordance with the specifications of the contract) for the first season at Rosetta Lock and they requested that they may lift the concrete blocks five days after manufacture and set them in site after 21 days, instead of the seven and the 31 days specified in the contract. This was agreed for the first season only to protect completed work at Rosetta.

The number of blocks made up to the end of this season was 1904 and 64 halves at Rosetta and 1797 and 30 halves at Damietta.

Blocks were set in Rosetta on a rubble bed $1/2$ m. thick concrete-in-mass was deposited in the mitres and splays. The blockwork was carried out satisfactorily and the joints were as tight as possible.

The contractors were late in setting the concrete blocks U.S. the apron of the first vent of Rosetta Barrage, and, as any attempt to go down to the required excavation level in the very short period remaining before closing down the works might lead to serious results following the appearance of springs in the bed of the river, they stopped setting the blocks in accordance with the contract drawing on the advice of the Resident Engineer, and laid them horizontally with the level of the concrete apron till they met the sloping line of the blocks, which ended the concrete block apron on the upstream of the Barrage. This was a temporary measure for flood protection and during the next season, these blocks had to be taken away and set in accordance with the contract design.

GRANITE MASONRY

Rosetta.

Building granite masonry began on 12th May, 1937 and the method adopted in building the facing, backing it with concrete-in-mass, and pointing, complied with the provision contract.

Firm instructions were given to insure that pointing was executed by skilled masons.

On their request, contractors were allowed to deposit concrete-in-mass in walls during the night as from 2nd June, 1937 to be able to go up with the walls to R.L. 16. before the advent of the flood.

It was possible in the first week of July 1937 to go up with the walls U.S. the main culverts to R.L. 15.10, but the progress in masonry in the D.S. portion was slow until after the steel tubes of the subway were finally adjusted and the 1 : 4 concrete of the main culverts was laid.

Contractors gave up all hope of the possibility of going much above R.L. 14.50 with the masonry work, but the Resident Engineer insisted that walls be kept well ahead of the flood level and deposition of concrete during the night was allowed on the understanding that the walls would be built to R.L. 16.00.

Moreover, they were allowed after reference to the Consulting Engineer to deposit concrete in the arch rings of the main culverts of the lock after three days instead of seven as specified by the contract.

Masonry facing and concrete hearting proceeded during flood up to R.L. 18.30. The contractors erected 4 steel temporary bridges across the lock to continue work during flood and used decauville trucks for concreting the walls instead of the derricks erected on the left bank which were used in this work before the flood arrived.

This work ceased on the 30th of August, 1937.

As the bolts to fixe the cast iron grooves in the half pier were not available a notch was left, and its facing was built in brick masonry in lime and homra mortar as a temporary measure. This masonry will be easily removed next season and concreting will be carried out whilst fixing the bolts of the grooves.

Three construction joints, two between the gates and one downstream the D.S. gate, were made in the river wall.

Seven construction joints were made in the land wall located as follows :—

2 joints were put upstream the upstream lock gate.
2 joints were put between the U.S. & D.S. lock gates.
3 joints were put downstream the downstream lock gates.

These joints started at the surface of the concrete floor and continued to the top of the walls. The further of the 2 joints beyond the upstream gate was at about R.L. 12.70, i.e. about 1.70 m. from the surface of the concrete foundation. This was due to a delay in the orders given to the contractors to construct this joint.

As the grease put in the expansion joints stained the ashlar facing, the Resident Engineer after referring the matter to the Consulting Engineer ommited it from the side joint of the ashlar facing and replaced it with compressed building paper and used grease on the concrete faces of joints only.

In accordance with the advice of the Consulting Engineers, the vertical joint at the back of the ashlar, i.e. on the side of the concrete hearting of the wall, was pointed with cement previous to depositing the concrete of the second section which formed the construction joint.

Generally the spacing of the construction joints was between 35 m. and 40 m.

Damietta.

The building of granite masonry began on 27th June, 1937 and continued up to the end of the season (29th August 1937), and it was possible to complete the U.S. & D.S. gate recesses, the U.S. temporary dam, U.S. & D.S. inlets of U.S. temporary dam, U.S. & D.S. inlets of culverts, the inlets of filling culverts, and six courses of both of the land and return walls. Concrete backing a metre wide was laid in the river wall up to R.L. 12.70. A recess was left to receive the culvert.

Three construction joints were made in the River wall: two of which were put in between the U.S. & D.S. lock gates and one beyond the downstream lock gate.

Nine construction joints were made in the land wall located thus:

- 5 between the U.S. lock gate and the old lock.
- 2 between the U.S. & D.S. lock gates.
- 2 D.S. the D.S. lock gate.

Subway Under Locks.

As it was late to obtain the steel tubes from abroad, the Consulting Engineers agreed to local manufacture from Thomas normal steel, provided it was thoroughly sound. The order was given to Messrs. Thomas Cook & Son.

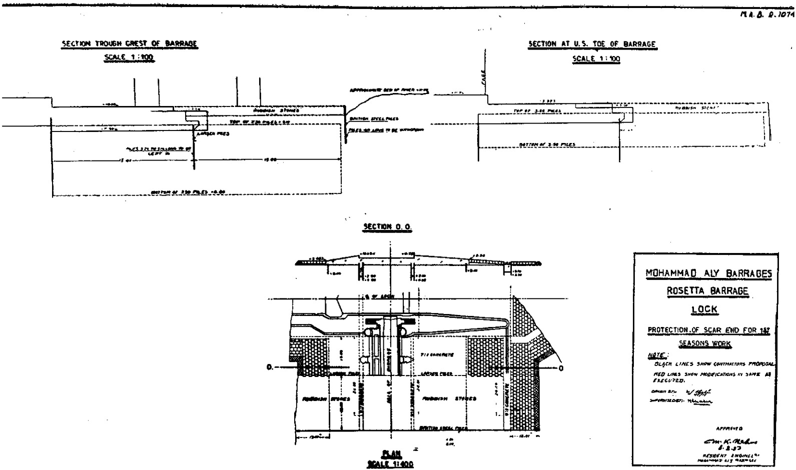
As the standard plates found in the Egyptian market were six feet long and he standard angles $4 \times 4 \times 1/2$, the Contractors were allowed to use them instead of using plates of 2.00 long and angles of $4 \times 3\,1/2 \times 5/8$ as stipulated in the Contract but the Contractors were asked to stiffen the angles at intervals which they did.

Rosetta Subway.

The total length of the horizontal tubes as erected was 22.17 m., of which length 12.08 m. were on the right hand side of the centre-line of the lock and 10.09 m. on the left. The total length as specified was 22 metres, of which lengtt 12.00 metres were to be on the right side and 10.00 on the left side but the discrepancy has no effect on the superstructure.

After adjusting the vertical shafts it was observed that the shaft on the river side was out of plum and this was remedied by putting a tapered horizontal ring in between two of the sections forming the total length of the vertical shaft.

The horizontal tube was tested under a head of two metres by filling it with water and letting water rise in the vertical shaft to a height of two metres and the joints proved to be watertight.


M.A.B. D.1074
SECTION TROUGH CREST OF BARRAGE
SCALE 1:100
RUBBISH STONES
BRITISH STEEL PILES
LARSEN PILES
SECTION AT U.S. TOE OF BARRAGE
SCALE 1:100
RUBBISH STONES
SECTION O.O.
RUBBISH STONES
LARSEN PILES
BRITISH STEEL PILES
PLAN
SCALE 1:400
MOHAMMAD ALY BARRAGES
ROSETTA BARRAGE
LOCK
PROTECTION OF SCAR END FOR 1ST
SEASONS WORK
NOTE:
BLACK LINES SHOW CONTRACTORS PROPOSAL
RED LINES SHOW MODIFICATIONS AS SAME AS EXECUTED.
APPROVED
RESIDENT ENGINEER
MOHAMMAD ALY BARRAGES

Rosetta Subway.

These were found to be 6 cms. longer than the designed length and the difference was divided equally on the two sides.

The level of the horizontal tube after being adjusted was found to be 2 cms. higher than the design.

Pitched Banks.

Pitching was made in Rosetta left bank inside the temporary sudd, U.S. & D.S. the lock. The portions nearest to the lock for a length of 75 ms. U.S. and 45 ms. D.S. measured from the salient angles of the return walls were built in 4:1 cement mortar and beyond the 75 ms. upstream it was built dry for a length of 57 m., and below the 45 ms. downstream it was built dry for a length of 45 metres.

Excavation for the toes of the pitching was carried out down to R.L. 9.50, where sand appeared increasing the designed depth by ½ m. The toe was enclosed between two wooden shutters and dry rubble laid in it and then rubble built in mortar. That part of the toe, built in mortar, was above the level at which the subsoil water was kept by pumping.

A layer of ballast 0.15 m. thick was laid under the stone pitching to prevent the removal of earth by wave action, or otherwise, from below the stone and through the interstices.

With view to increasing the percolation length for the next season's sudd, contractors inserted concrete diaphragms going deep in the bank under the toe and under the pitching as shown on sections. These diaphragms are located at 50 m., and 62.5 m. measured from the salient angle of the U.S. return walls.

Instructions were given to contractors to build two stairs U.S. the lock, one just U.S. the return wall and the other 50 m. further to the south and also to construct one stair D.S. the lock; the steps from R.L. 14.00 to R.L. 15.00 to be made from Batn el Bakara stone and above R.L. 15.00 from Isawia stone.

Scar Ends and Protections.

A drawing shows the provisions adopted in protecting the scar end at Rosetta together with the original proposals of the contractors. They are considered ample protection during flood.

A drawing shows the precautions taken at Damietta and as there was not ample time to place the concrete blocks outside the concrete floor, rubble stone was built in some places and dumped in others around the exposed floor.

With regard to protection for Nile banks it was arranged to fill the banks previously cut with earth watered and rammed to a temporary type. The Damietta bank was also pitched with stone as a temporary measure.

Instructions were given to contractors to hold in stock at both Rosetta and Damietta Branches rubble stone and sand bags and to keep at each of the two branches a tug and a barge or two big native boats for use in cases of emergency. Arrangements were also made to keep a party of Government engineers employed in making soundings in both branches of the River where the finished works existed

Rayah El-Behera.

With regard to pitching of the noses at the entrance of Behera canal the contract stipulated to make them in the dry, but the contractors raised the point that such work could not be done in the dry as the great depth of water in the River at the site would not allow it. They submitted sections and drawing supporting their proposals, but on checking, these sections were found to be wrong and correct sections showed that the work could be done in accordance with the contract.

Borings made at the site of the head regulator showed that the strata of soil under the foundations was unreliable, and new borings were made at a distance of 210 m. D.S. the proposed site which showed sand at R.L. 7.00. The Consulting Engineer and the Resident Engineer agreed to the Contractor's request to shift the proposed site to where sand appeared.

Owing to lack of staff and plant the contractors will not be able to carry out any work on the Rayah El-Behera during this season.

LABORATORY SECTION

Foreword.

The work in the Laboratory of testing materials is divided into three different parts :—

1. To arrange before hand the proportions of materials to be used and to show how the different proportions could be easily obtained in practice and frequently to check the measurement in the field to ascertain whether the proportion of the different materials are in accordance with the contract requirements.

2. To make tests on the cement, concrete, mortar, ballast, sand, etc., actually used in the works.

3. To carry out researches in the different problems which are generally met with in practice.

Although much attention is given to the first two points mentioned above, yet remarks on the research work will be found both useful and interesting.

All experiments done in part 1 and 2 are done strictly according to the contract specifications and also according to the British standard 1931 specification of testing cement. If there is any criticism to be made against the specification it is stated in the last part of this memorandum.

Great attention is paid to the compression test. In fact it is given first attention for reasons specified hereafter.

In these modern days great attention is paid to the money value of the different constituents of concrete. A thorough knowledge and analysis of the different materials of concrete and mortar will lead surely to conspicuous economy of material and effort.

The old method of illusory constants and permissible stresses should be avoided by the modern engineer who can fix his own stresses to the different kinds of concrete. Sometimes the concrete is wanted to be water-tight, and sometimes it may be wanted to be dense and strong. Too much cement is not always welcomed.

The existing standard specifications of cement testing should be changed; compression tests should replace the old fashion useless tension tests and mechanical devices should replace hand labour in preparation of samples.

A special apparatus is made by means of which one can obtain a fixed temperature and a fixed humidity or even fog whenever it is so desired. This machine will be of help in carrying out some of the tests as in contraction and expansion of concrete and cement, setting time of cement; etc., etc..

It is essential for the Engineer to know the kind of concrete to fit each case in practice and proportions of aggregates should be given great attention.

In what follows I will try to give a short report on the above as well as an explanation of the effect of each quality of cement and on some more detailed especifications on limestone and other materials which do not usually form part of our specifications in Egypt.

The scope is wide and these notes cannot cover the entire aspects of the several subjects.

PART I.

Before going into details of proportioning and measurements it is essential to give a hint about the place of supply of different materials and the grading required for each material.

Ballast and sand for concrete and mortar were supposed to be obtainable from sites on the western fringe of the desert about 21 kms. north of Delta Barrage. Trial pits were dug out to ascertain the quality of material, samples were taken and approved; but the attention of the contractors was drawn by the Resident Engineer just before the start to an area which contains an ample quantity of ballast and sand at Birkash about 10.00 kms. north Delta Barrage.

The location of both areas is shown on the attached map.

The material from the new location was analysed and found to be proper.

Here is a comparison between the new and old quarries and also between Khatatba quarry for sand and the new one.

New Quarry and its Location.

1 — Near Delta Barrage and about 10 kms. to the north.
2 — Railway and Nile transport can be used.
3 — The Ballast is found naturally separated from the sand.
4 — Ballast as found is of good gradation complying with the contract specification.
5 — Sand is desert clean sand and well graded.
6 — Work in quarries can be continued throughout the year without stoppage.

Selected Quarries at old Location as Shown on Contract Drawings.

1 — They are 21 km. north of Delta Barrage.
2 — Railway and Nile transport are more expensive.
3 — Ballast found at the site is mixed with sand.
4 — Ballast as found is not of good gradation and has to be sieved.
5 — Sand is mixed with ballast.

Khatatba Sand Quarry.

1 — It is about 37 kms. north of the Delta Barrage.
2 — Nile transport only is available and is more expensive.
3 — Sand is well graded although a bit coarse.
4 — Work in quarries must cease during flood time as the area is inundated.

The analyses are shown in part «2».

Measurements of Concrete Aggregates.

Concrete aggregates are specified to be graded generally in accordance with the following tables and the approximate percentage of the various sizes of stone and sand are, subject to the approval of and possible modification by the Resident Engineer to be in accordance with the following.

MOHAMMED ALY BARRAGE CONTRACT.

	Percentage	Retained by a ring	Pass a ring
Ordinary Concrete	33 %	—	1/8" dia.
	12 %	1/8" dia.	1/2" »
	20 %	1/2" »	1" »
	20 %	1" »	1 1/2" »
	15 %	1 1/2" »	2" »
Fine Concrete	33 %	—	1/8" dia.
	12 %	1/8" dia.	1/4" »
	20 %	1/4" »	1/2" »
	20 %	1/2" »	3/4" »
	15 %	3/4" »	1" »

The aggregate for reinforced concrete must pass a 3/4" inch ring and be graded on similar lines to the above.

The proportions of aggregate (i.e. broken stones or ballast and sand duly mixed) to cement for the concrete, and proportions of sand to cement for mortar required for the different portions of the work, are to be applicable to the volumes of dry materials, i.e. aggregate or sand to cement before the admixture of water therewith.

Birkash Ballast.

The ballast from Birkash, as found in nature, when analysed proved to be of the grade required by the contract as shown above. The Contractor did not have an ample time to order mechanical devices for grading the ballast, but finding that the ballast well graded the Resident Engineer approved its acceptance on condition that it was sieved in the quarries to get rid of the fine sand, ballast, and dirt. The quarries are supplied with special (of small mesh) set of sieved inclined at an acute angle to the earth to eliminate the fine material.

قناطر محمد على

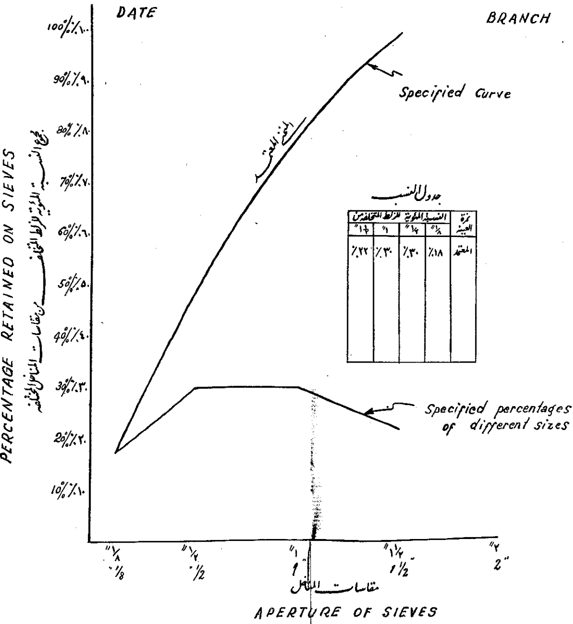
MOHAMMAD ALY BARRAGES.

معمل اختبار المواد

LABORATORY OF TESTING MATERIALS

تحليل عينات الزلط العادى

ANALYSIS OF SAMPLES OF ORDINARY BALLAST "2" GAUGE.



جدول النسب

نمرة العينة	"⅛	"½	"١	"١½
	النسبة المئوية للزلط المتخلف من			
المعتمد	٪١٨	٪٣٠	٪٣٠	٪٢٢

قناطر محمد على

MOHAMMAD ALY BARRAGES

معمل اختبار المواد

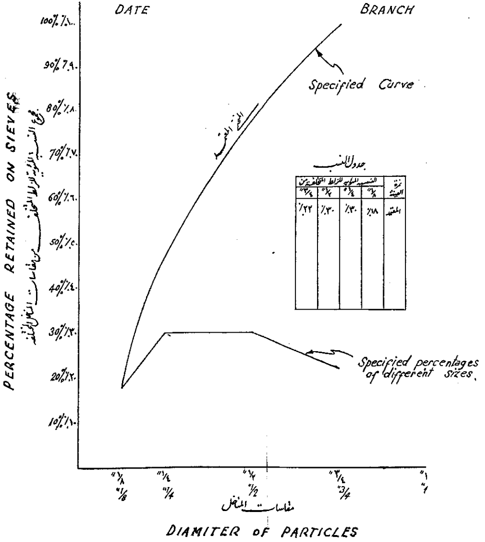
LABORATORY OF TESTING MATERIALS

تحليل عينات الزلط الرفيع

ANALYSIS OF SAMPLES OF THE FINE BALLAST "1" GAUGE

تاريخ
DATE

فرع
BRANCH



جدول النسب

نمرة العينة	النسبة المئوية للزلط المتخلفة من			
	"1/8	"1/4	"1/2	"3/4
المعتمد	٪١٨	٪٣٠	٪٣٠	٪٢٢

The Ballast is tested before loading, a known quantity of ballast is taken and analysed to find the proportions in volume for each gauge separately.

How to Fix Proportions of Aggregates (Ballast and Sand).

From the above it is noticed that the percentage of the sand to the ballast is 50%; the sand being 33% of the whole mixture.

Several experiments were made to find the increase in bulk of a given quanity of Ballast when mixed with a quantity of sand equal to 50% of its volume: **the mixture being done dry.** Thus a half metre cube of ballast is added to quarter of a metre cube of sand and thoroughly mixed. Then the mixture is measured again and the excess is noted.

Average excess is noted to be 20% and the amount of cement is fixed accordingly.

Thus to get the proportion of 7 : 1 concrete for example the procedure was as follows :—

A batch of 0.50 m^3 is wanted; this being the capacity of the hopper of the concrete mixer.

To get an even number of cement bags per batch, start with a fixed quantity of cement say 2 bags.

$\therefore$ Vol. of cement $= 2 \times 0.03571 = 0.07142$ m^3
(one cubic metre contains 28 bags of cement see explanation in Part 2.)

Vol. of mixture $= 0.07142 \times 7 = 0.49994$ m^3

(Vol. of ballast) + (20% of Vol. of ballast) $= 0.49994$ m^3

$$\text{Vol. of Ballast} = \frac{0.49994}{1.20} = 0.416 \text{ m}^3$$

Vol. of sand $= 50\%$ Ballast $= 0.208$ m^3

and so on with any percentage required. The following table gives the different quantities :

Material	MIXTURE OF ONE BATCH			
	7 : 1 Concrete	6 : 1 Concrete	5 : 1 Concrete	4 : 1 Concrete
Ballast	0.42 m^3	0.45	0.45	0.42 m^3
Sand...............	0.21 m^3	0.22	0.22	0.21 m^3
Cement	2 Bags	$2^1/_2$ Bags	3 Bags	$3^1/_2$ Bags

Mortar.

Several experiments were made in the laboratory to get the proportions of sand and cement for the different mixtures of mortars.

The sand is measured dry and the definite proportion of cement is added. The proportions are usualy specified in volume but the cement being compressible the weight of the required fixed volume of cement is calculated. The quantity of cement is then fixed by weight accurately.

One bag of cement = 0.0357 m^3.
having 28 bags of cement per one cubic metre.

Each batch is mixed with water to give the consistency as used in ordinary practice.

The following results were obtained:

Mortar	Volume of Mortar Given by one Bag of Cement
1 : 1	0.0516 m^3
1 : 2	0.0816 m^3
1 : 3	0.1137 m^3
1 : 4	0.1430 m^3
1 : 4 & above	Vol. of mortar = vol. of sand with no extra bulk.

Measuring Hoppers — Truck — Etc.,

The hoppers of the concrete mixers are carefully marked with welded steel strips measuring the quantity of Ballast. The sand is measured by boxes each 0.50 × 0.50 × 0.42 m. for 1 : 7 & 1 : 4 concrete and varies with the varying percentage of concrete according to the table showing the said percentage.

The decauville trucks are marked in a similar manner.

Ballast and Sand.

Samples are usually taken from each shipment to be thoroughly analysed and the results are put on record. Any change from the specified grading is noticed and the shipment is either rejected or else the grading put right.

Also samples are taken from the ballast before being put in the mixers and are tested. It was noticed that the method of stacking the ballast in high heaps might result in getting a badly graded stock of ballast; as large sized ballast tends to come down at the foot of the heap leaving a middle core of fine not graded ballast.

Concrete.

Slump tests for concrete were made daily in the field to determine the quantity of water necessary for the mixture. A slump of 2" was considered desirable and the quantity of water was always arranged accordingly, to suit the weather, the materials of the admixtures if they are wet or dry, and the conditions and the location of the poured concrete. On hot days the slump test was made more than once a day, and it was found on one of the warm days in July that it was necessary at noon to use sixteen gallons per batch, while in the morning of the same day fourteen gallons only were necessary per batch. The class of concrete was the same in both cases 1 : 7 and the aggregates were the same and also the ballast was continually kept wet. The cause of this was the heat absorbed by the sand and the ballast. The sand usually contained a certain amount of moisture which varied with the humidity and heat.

A slump of 2" means the decrease in height of the concrete column after depositing it from the slump mould and it was found that 2" gave a consistency o sound dense concrete easily worked.

Other Tests on Concrete : Samples were taken daily from the concrete discharged from the mixers to represent every section of the work and also for different classes of concrete. Results and details will be shown in Part 2.

LIMESTONE.

The limestone, like other materials, was always examined.

Bad stone was immediately rejected and not allowed to be used in any part of the permanent work. It was found that a certain percentage of stone was badly weathered and dissolved when put in water, and the Contractors were asked to change the quarries and supply stone from Government quarries. The characteristics of the stone are shown in Part 2. Available specifications are inadequate and the writer tries later to give proper specifications for such stone.

Bricks.

Bricks are to be used in the Tawfiki Regulator Reconditioning, Hydraulic Research laboratory, Zomor Syphon and other minor works.

Ordinary bricks made in Egypt are of poor quality. The bricks are made of clay which is shaped in small wooden forms by hand labour and are then left to

dry for some time. The dried bricks are laid in courses in a special order with coal in between the courses making a «kiln», and then fired and allowed to burn. The bricks made by this method can be hardly of sound good quality and are not fit for big works, which need durability to stand the effect of wear, and except when the bricks are made by very skilled men and made in the proper way, these are not fit for irrigation works, bridges, etc.

Machine made bricks are superior as special kinds of clay are selected and then a certain amount of the clay is put in a pit and watered. The percentage of water depends upon the kind of clay and its plastic state. This mixture is left for a few days and then moulded in the machine.

The machine consists of a big pot which is kept rotating, and fed with clay continuously by means of an endless chain or belt device. The pot has holes in the bottom and another device inside to squeeze the clay through the holes, which then falls into another drum to be mixed again to a homogenious paste and passed to a small steel chamber with a helical screw of wide pitch to force it through the required mould in a small adjacent chamber. The shaped mixture is cut as it comes out of the last chamber.

The bricks are then kept in shade in special galleries for some time before being burnt.

A small machine of the above mentioned type can make about one thousand bricks an hour. Different designs of bigger machines are used in Egypt.

It should be noticed that the bricks moulded by machine should be "stiff mud brick" i.e. brick moulded from clay in the condition of stiff mud, while the bricks moulded by hand have to be of soft mud. The ordinary kilns made in Egypt give three grades of bricks. The kilns are of the old style up-draft-kiln and the bricks are classified according to the position in the kiln. Three grades are taken, the arch brick, the body bricks and the pale brick. The arch bricks are those which form the tops and sides of the arches in which the fire burns, they are overburned, hard but brittle. The body bricks are those taken from the interior of the pile and are the best grade. The pale bricks are those which form the exterior surface of the kiln and are pale in colour, underburned and too soft for ordinary work.

Tests Made on Bricks.

Several tests were made on the different kinds submitted by the different contractors; the results were unsatisfactory and the contractors brought wire cut bricks (Kebesh make) in place of ordinary bricks. The wire cut bricks are of ordinary clay but of course machine made and saved much trouble and waste from broken and rejected bricks.

Results of tests as well as a short new specifications are detailed in Part 11.

Washing of Ballast and Sand.

Attempts were made to wash them in stacks by means of a hose but this was always difficult and usually impossible to carry out properly, as the materials washed from the upper layers were carried down by the stream of water to the lower portions where they remained. Another method was shovelling sand and or ballast into one end of a V trough, washing it down with a hose and endeavouring to carry off the finer materials in the run off water, and for a large quantity of material a combination of a trough of this kind with an ejector has been successfully used. A concrete mixer has also proved adaptable to this kind of work, water being turned in and the mixer allowed to overflow while the drum in rotation. Necessarily all of these processes are somewhat expensive and add to the cost of the aggregate, but where tests indicate that the quality of concrete will be seriously affected by the uncleanliness of sand or ballast, it should be undertaken without hesitation even at increased cost. The method that was adopted for washing ballast at Mohammed Aly Barrages is as follows :—

A decauville truck was drilled with holes on both sides and at the bottom and equipped with an iron grid at a small distance above the bottom of the truck, and while filling it with ballast water under pressure was sluiced on the ballast. The washed ballast was dumped on wooden tables and rewashed before taking it to the mixers. The wooden tables were punched with holes and raised a few centimetres above ground level to allow the water to drain taking with it the dirt.

PART II & PART III

These two divisions will be dealt with here together to give a better grasp of the subject than they would if separated. The subject will be arranged in the following manner:

1 — CEMENT —

Full discussion on the several tests of cement.

(a) Effect of Fineness on neat cement and sand-cement mortar.

(b) Effect of soundness.

(c) Setting time.

(d) Tension tests "neat & mortar".

(a) Fineness of cement is determiened by special sieves of special standard wire cloth woven carefully and mounted on special frames. Whenever possible the sieve should be tested by counting the number of openings per lineal inch. To attain this the following method may be adopted.

A squared cut 1" × 1" is made in a paper which is then gummed to the surface of the sieve. A light is then put against the sieve and the number of meshes may be counted from the shade transmitted on a board.

Influence of Fineness on Strength of Cement, Mortar and Concrete.

Tests in this laboratory on portland cement made at Tura show that the tensile strength is decidedly effected by the fineness factor and the final results are such that:

1 — The strength of neat cement is lowered by finer grinding.

2 — The strength of sand — cement mortar is increased by finer grinding.

3 — Tests will be made in future to get the effect on the concrete

The tables below show the average results of tests made.

Age		RESIDUE ON SIEVE 170	
		10.00%	2.00%
		lbs / in.^{2}	lbs / in.^{2}
Neat Cement	One day	725	665
	7 days	1360	1268
	28 days	1384	1330
	3 months	1458	1388
	One year		
Cement-Sand 1 : 3	One day	285	308
	7 days	540	588
	28 days	555	632
	3 months	693	700
	One year		

It must be stated here that the sieve test does not show the amount of flour in the cement. Special apparatus is designed to get the percentage of the flour in the cement but the trouble is the lack of standardization

Also it should be noted that the unit weight of cement decreases with its fineness.

(b) **Soundness. Its Measurement.**

The British Specification calls for using le-Chatelier moulds for testing soundness. The mould does not give actual expansion or contraction but gives only comparative results for different brands of cement. The moulds also are liable to get wrong easily. The expansion and contraction of cement during hardening may be measured however, directly and very accurately by means of Bauschingers Apparatus. The apparatus consists of a stirrup-shaped calliper, having a fine micrometer screw on its right arm and a sensitive lever on the left. The short part of the bottom is supplied with a blunt calliper point and is presssed against the measuring screw by a spring attached to the long arm. The micrometer can read to 1/1200 mm. special moulds are used with the apparatus. Dimensions of test pieces are 5 sq. cm. in cross-section and 10 cm. in length and are supplied with squared cavities at both ends, in which tiny steel plates, provided with centres to fit the calliper points, can be inserted.

The apparatus has been recently received and tests are not sufficiently advanced to give results. Some details on expansion and contraction will be given when dealing with concrete.

(c) Influence of Fineness on Setting Time.

In some instances the influence of fineness upon the time necessary for setting is noticeable. The effect is that the finer the cement the quicker it sets. The reason for this is explained by the fact that cements low in lime are often quick setting. When a sample is sieved with No. 170 sieve and analyses are made for both the coarse residue and the amount passing the sieve it can be found that the former is lower in lime than the latter. When the coarse residue is ground to a fine powder and mixed with the fine portion the cement will become quick in setting owing to the decrease of percentage of lime.

Our tests here proved the above theory and results shown below and also a table of the results given by Mr. Richard K. Meade.

Cement No.	Percent Passing No. 200 Sieve			
	75%	85%	95%	100%
	Setting time		(initial set)	in minutes
1	255	192	12	2
2	105	100	22	6
3	120	100	60	35
4	240	180	60	30
5	240	110	15	5
6	200	175	25	2

Results of Tests made on Portland Cement made in Egypt (Tura) & used on Barrages.

No. of Cement Consignment	Percent Passing No. 170 Sieve			
	90%	98%	90%	98%
	Initial Setting in minutes.		Final Setting time in minutes.	
81	100	12	215	210
82	120	20	220	200
83	120	30	215	210
84	105	40	215	215
85	110	15	210	200

The cement is sieved on sieve No. 170 and the residue is reground by hand labour in the laboratory and the necessary percentage are added to the cement passing the No. 170 sieve.

Tests were made also on the Final Setting Time of the Cement.

(d) & (e) Tension Test & Compression Test.

The British standard specification 1931 calls for tensile tests for neat cement and sand mortar. The neat cement tensile test was made optional in 1931, whereas our contract of Mohammed Aly Barrages made it essential. Tests show that tension for neat cement cannot be depended on as there are many factors affecting the results. However, cement mortar is never used structurally in such a way that they will be depended on to carry tensile stresses, while they are used to carry compression stresses. No relation whatsoever exists between the tension stresses and the compression stresses. The tension stress decreases with the age of the Briquettes while the compression stress increases.

TENSION TESTS.
NEAT CEMENT CONS.NO. 31
Long Period

Setting Time 100 min. in.

Water Consistenscy 28.5 % — Soundness 1 mm.

Fineness — 8.6 on sieve No. 170; 0.10 » » » 72 — min. in = (Minute initial)

1. d	28 d.	3Ms	6Ms	9Ms	1 Year	2 Years	3 Years	4 Years
1100	1200	1210	1170	1120	1270	....	....	....
1080	1150	1200	1060	1070	1070	....	....	....
1030	1120	1170	1030	1000	1070	....	....	....
1020	1050	1120	900	980	1020	....	....	....
1000	1030	1040	850	940	980	....	....	....
	1100	1148	1002	1022	1082	....	....	....

CONSIGNMENT No. 43

Water Consistency 28.5%

Setting Time 53 min. initia
3 - 13 final

Fineness 9.10 on sieve No. 170
0.10 » » » 72

Soundness 1 mm

1 d.	28 d.	3Ms	6Ms	9Ms	1 Year	2 Years	3 Years	4 Years
1280	1350	1400	1230	1280	1230	....	....	....
1190	1340	1340	1140	1210	1220	....	....	....
1190	1230	1250	1060	1210	1200	....	....	....
1190	1180	1230	970	1150	1140	....	....	....
1050	1140	1130	940	1100	970	....	....	....
1180	1248	1270	1070	1190	1152	....	....	....

HEAT CEMENT COMPRESSION
CEMENT CONS. No. 43.

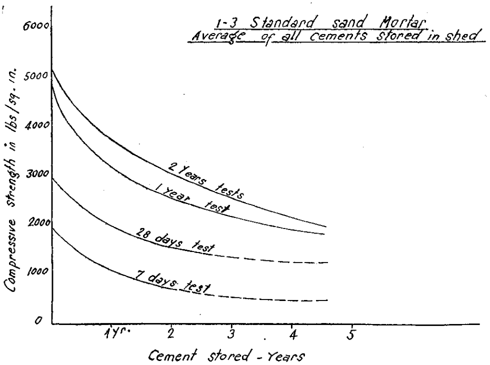
Cons.	Date of Gauging	No. of Cube	Date of Testing	Age	Wt. in Air Grams.	Wt. in Water Gr.	Volume CC.	Area	Crushing Load T	Stress lbs/''	Density	Wt. of fts/lbs	REMARK
43	2 - 10 - 37	5	9 - 10 - 37	7 days Test	809	450	359	7.869	30	8406	2.2537	140.9	
»	»	9			813	454	359	7.869	26.5	7426	2.2556	139.8	
»	3 - 10 - 37	17	10 - 10 - 37		803	447	356	7.804	33	9324	2.2556	141.0	
»	2 - 10 - 37	6	30 - 10 - 37	28 days Test	810	451	359	7.869	36	10087	2.2562	141.0	
»	»	10			823	462	361	7.913	38	10589	2.2797	142.5	
»	3 - 10 - 37	18	31 - 10 - 37		811	451	360	7.891	31.8	8846	2.2527	140.8	
»	2 - 10 - 37	1	2 - 1 - 38	3 Months Test	800	444	356	7.804	42	11869	2.250	140.5	
»	3 - 10 - 37	13			810	451	359	7.869	43.5	12036	2.260	141.1	
»	2 - 10 - 37	2	2 - 4 - 38	6 Months Test	798	442	356	7.804	46	12990	2.2107	138.2	
»	»	7			813	449	364	7.979	47	12980	2.2335	139.6	
»	2 - 10 - 37	8	2 - 7 - 38	9 Months Test	810	451	359	7.869	45.5	12745	2.2562	141.0	
»	3 - 10 - 37				810	451	359	7.969	38.0	10502	2.2562	141.0	
»	3 - 10 - 37				825	462	362	7.957	43	11915	2.2898	142.0	

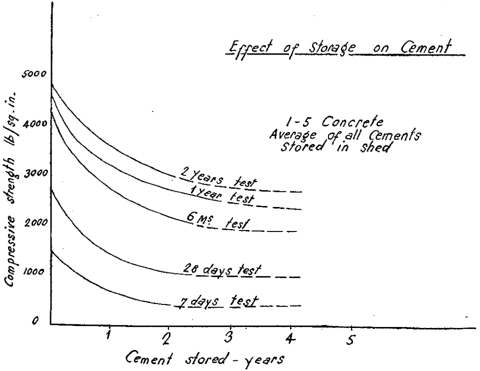
LONG PERIOD TEST CONSIGNMENT No. 12.

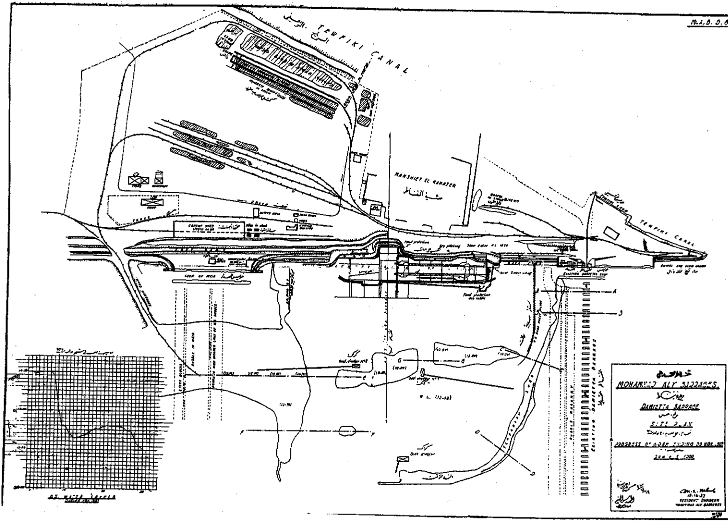
TENSION TEST.

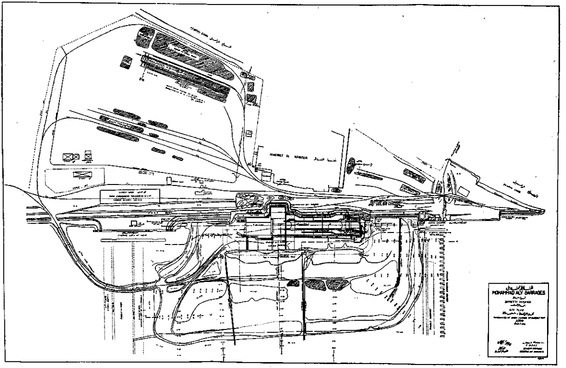
STANDARD SAND. 3 : 1 MORTAR.

Cons. No.	3 Days 8.5.37	7 Days 12.5.37	28 Days 3.6.37	3 Months 6.8.37	6 Months 6.11.37	9 Months 9 5.38	12 Months 9.5.38	2 Years 9.5.39	3 Years 9.5.40	4 Years 10.5.41	REMARKS
12	550	680	630	660	520	570	530				
"	540	650	630	630	520	560	520				
"	510	590	620	620	510	560	520				
"	490	580	610	620	500	560	510				
"	420	560	610	600	480	500	490				
"	420	450	600	580	480	580	—				
Mean in lbs/ins.	488	585	617	602	502	539	514				

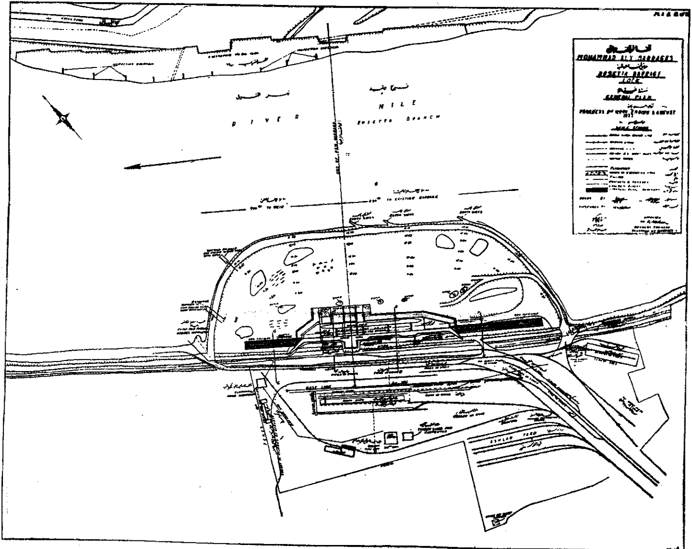

1-3 Standard sand Mortar
Average of all cements stored in shed
Compressive strength in lbs/sq. in.
6000
5000
4000
3000
2000
1000
0
2 Years tests
1 Year test
28 days test
7 days test
1 yr.
2
3
4
5
Cement stored - Years


Effect of Storage on Cement
1-5 Concrete
Average of all Cements
Stored in shed
Compressive strength lb/sq. in.
5000
4000
3000
2000
1000
0
2 Years test
1 Year test
6 Ms. test
28 days test
7 days test
1
2
3
4
5
Cement stored - years

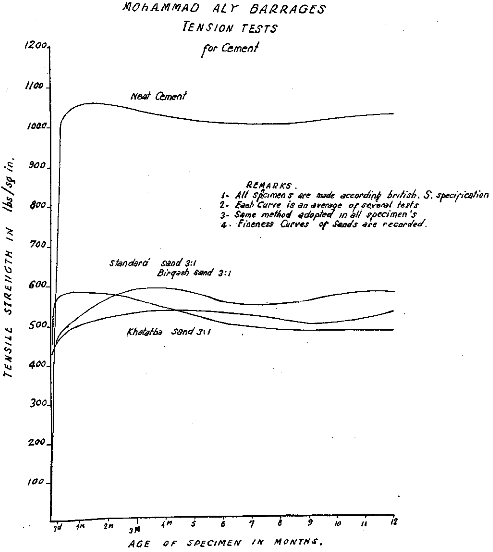

M.A.B. D. 89
TEWFIKI CANAL
MANSHIET EL KANATER
LOCK OF WEIR
EXISTING DAMIETTA BARRAGE
W. L. (13.33)
CEMENT SHED
AF WATER LEVELS
MOHAMMED ALY BARRAGES.
DAMIETTA BARRAGE
SITE PLAN
PROGRESS OF WORK ENDING 30 NOV. 937
RESIDENT ENGINEER
MOHAMMED ALY BARRAGES



MOHAMMAD ALY BARRAGES
SITE PLAN
MANSHIET EL KANATER



MOHAMMAD ALY BARRAGES
GENERAL PLAN
RIVER
NILE
ROSETTA BRANCH


MOHAMMAD ALY BARRAGES
TENSION TESTS
for Cement
1200
1100
1000
900
800
700
600
500
400
300
200
100
TENSILE STRENGTH IN lbs/sq in.
Neat Cement
REMARKS.
1- All Specimens are made according british. S. specification
2- Each Curve is an average of several tests
3- Same method adopted in all specimen's
4. Fineness Curves of Sands are recorded.
Standard sand 3:1
Birqash sand 3:1
Khatatba sand 3:1
7d
1M
2M
3M
4M
5
6
7
8
9
10
11
12
AGE OF SPECIMEN IN MONTHS.

The report of the building Research Board for the year 1931 states « that the crushing strength of Mortar is a better guide to the crushing strength of Concrete than the transverse test of mortar, and that the transverse test of mortar is a better guide than the tensile test».

Time will come when compression tests will replace this standardized tension test and mechanical devices will replace hand made briquettes.

It is also noticed that the strength of neat cements, as stated before, varies with the fineness but vice versa with the variation of strength in sand-cement mortar. It is to be noticed also that the rate of increase of strength of the coarse specimens in the long period test both in neat cement or in mortar, is greater than the rate of increase of strength of fine specimens. This is due to the fact that the large particles take more time to hydrate.

Effect of Storage on Strength of Cement.

The structural materials research Laboratory U.S.A. made extensive investigation of the effects of storage on the strength of mortar and concrete. They found that there is an appreciable loss in the strength of cement due to storage. This effect is shown on a curves diagram.

Tests will be made on the cement made locally in Egypt for a long period to cover five years. The deterioration in the cement is caused by the absorption of atmospheric moisture which causes partial hydration of the cement.

Cement Tests at Mohammed Aly Barrages Laboratory.

It addition to the tests of the cement made at Tura other tests are made at Mohammed Aly Barrages Laboratory for each consignment.

During the first season no consignment has been rejected but few of the consignments were found to be coarse, having the residue on sieve No. 170 of little more than 10 °/o. The attention of the cement company was drawn to this fact and instructions were given to the effect that the cement must be finer.

The cement is kept in special sheds of dimensions 21 x 90 ms. and made of steel columns supporting steel strusses. Zinc Plates are used as cover for the roof trusses and as protection on the sides. A space of one metre depth at top of the sides of the shed is fitted with wire mesh to keep air circulation. Catchment drains surround the shed to carry away water and the floor of the shed is made of timber supported on big sized filleries and the space between them is filled with broken bricks or stones etc., to avoid any damp. A railway line runs right through the shed, dividing it into two parts to facilitate loading and unloading of railway waggons, and connecting it with the main railway line.

Tests made in the Laboratory include compression tests, expansion and contraction tests for mortar, concrete, bricks, limestone. Grading tests for sand ballast are also made.

Conclusion to Tension Tests.

1 — The tension test has no relation to the crushing strength.

2 — Low stresses in tension in the early days do not show that the cement is of poor quality.

3 — Different operators obtain different results for tension tests due to lack of standardization in making the briquettes.

4 — Old briquettes are brittle and the least error in applying the load eccentrically will cause a wide variation in stress.

5 — The lack of standardization of determination of flour in cement, which causes high tensile strength at early dates due to immediate activity of flour on hydration as stated before.

6 — Tensile tests should be replaced by standard compressive tests of say 1:3 mortar which should be shaken or beaten down with a standard mechanical device :

Result of Tension Tests of Tura Cement.

As a result of many consignments of Tura cement (each consignment is of 250 Tons) show the tensile strength of neat cement at 7 days is usually above 1000 lbs/in^2 and the tension test of 1:3 mortar is above 300 lbs/in^2 after three days and above 400 lbs/in^2 after seven days.

Laboratry Equipment.

1 — Compression machine for concrete, cement etc., of a capacity of 200 tons operated by hand for materials of low ductility. It is supplied with special tension attachment complying with B. S. specifications and of a capacity up to 700 kgs. (Amsler make).

2 — Compression machine as above (supplied by the contractor). Capacity 80 tons Tension apparatus does not comply with B. S. S.

3 — Tension machine (Adie) for cement briquettes; tests up to 1. 500 lbs. per sq. in.

4 — Bauchinger's Apparatus for measuring expansion of small cement parallelopipedons 100 mm. long (description already given).

6 — Shrinking testing apparatus for cement or concrete Prisms. Amsler make and description will be given later.

6 — Special designed machine and made in the Government workshops of P.W.D. Cairo; complete details will be given of this machine and its use later.

7 — 2 Vicat needles with accessories and spares; 36 briquette-moulds with plates.

8 — 24 moulds for concrete supplied by the Covernment
48 » » » » » » Contractor.

9 — Special over gas heated.

10 — Balances : (a) Sensitive Balance weighs 100 grams. (Sensitivity to 0.001 gram).
(b) Sensitive Balance weighs 20 kgs (sensitivity to 0.15 gram).
(c) Balance weighs up to 50 kgs.
(d) Balance weighs up to 10 kgs. (not very sensitive).

11 — One set of sieves for sand; Nos. 100. 62,25, 14 & 7, 100, 62, 52, 25,14.

12 — Two sets of sieves for sand; Nos. 10,20,30,40,50 and 76 with cover and receiver.

13 — Two sets of sieves for cement 72 and 170 with cover and receiver.

14 — Meshes for Ballast.

15 — Chatelier's Calipers and tank.

16 — Benzine Burner.

17 — 4 spatulas and six trowels etc.

SAND.

Sand is essentially rock fragments crushed or eroded to small fragments by the effect of weather, water action, glacial action or disintegration. The minerals in the sand are quartz or silica, felspar, mica and other minerals. The quartz sand comes from sand stones which are composed of quartz grains cemented by iron oxide, calcium carbonate, or clay.

(1) Hard sandstone: quartz cemented with iron oxide, (this kind exists at Aswan)

(2) Sandstone with the calcium carbonate as a cementation material, as that of Abbassia, may be disolved in water and is not fit for works under water.

(3) Sandstone with the clay as a cementing material is of poor quality and has a very low crushing strength.

(4)There are other kinds but they are very rare in Egypt.

Desert and Water Sands.

The difference between the desert sand and the water sand is that the former has its grains rounded while the latter has its grains angular in shape with rounded ends. The belief that angular form of the grains whether in sand or

ballast gives more strength than that given by the rounded grain is not formed on sound bases. The rounded grains can fit each other in a better way and voids can be more readily filled with cemented material to form denser mortar or concrete. Moreover the sharpness quality is hard to indicate and hard to standardize.

Cleanliness of Sand.

In order that cement may adhere to sand grains or coarse aggregates, the particles of sand should not be coated by any foreign substance which may interfere with the necessary bond or change the chemical action. Red water from the Nile during flood used in tension and compression tests in the laboratory did not affect the strength in any way. But the same water, if used in large quantities and for a long time in wetting the surface of concrete, for example, which has to receive a second top layer, may leave a thin film of clay in between the two layers. This film should be removed or otherwise there will be a defect.

In lean mortars, a small percentage of clay in sand might increase the strength because the clay helps to fill in the voids, while in rich mortars it decreases the strength because the clay reduces the cohesion.

Discussion of Mud - Mortar Stress.

Observation on the two diagrams ar shown below : —

(1) **Chemical Laboratory**

(a) It is not stated whether they adopted the same consistency in all the tests or the same percentage of water. The former was done and it was left to the judgment of the operator and should be generally adopted to get results which can be compared.

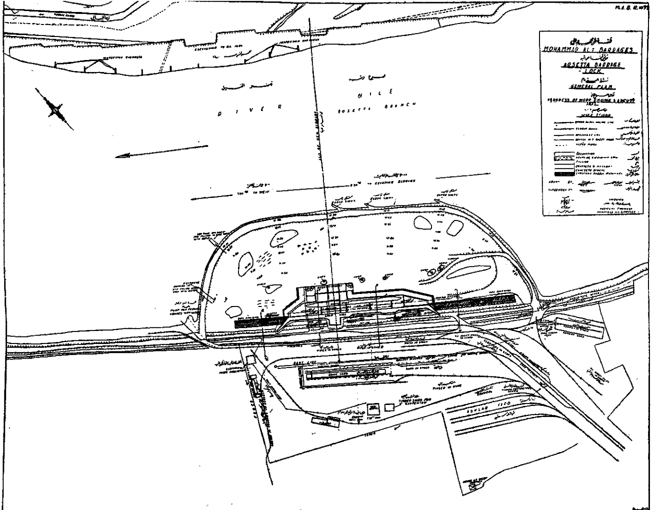
(b) It is noted that the test is made with standard sand so as to keep similar conditions to all tests.

(2) **Mr. Harry Stanger Tests.**

(a) The same consistency is adopted in all tests.

(b) Miami — river sand is used and information about this sand is lacking. If it is a graded kind of sand then the effect of the mud is to prevent cohesion because there is a minimum of voids. In the standard sand which is of equal sized grains practically, and there are more voids and a small percentage of mud may help in filling in the voids and giving higher stresses. This is the explanation of an increase of stress with 10% addition of mud in the chemical laboratory tests.

In my opinion compression tests are those which have to be adopted in place of tension tests. The results will be shown when tests are complete.


MOHAMMAD ALY BARRAGES
ROSETTA BARRAGE
- LOCK
GENERAL PLAN
RIVER
NILE
ROSETTA BRANCH

Organic Matter; such as loam appears to affect the strength of mortar as shown by Prof. Abrams and Dr. Harder in their tests. Mica is also objectionable especially mica schist which is not fit at all as large aggregates. Mica is scaly in structure and has a low crushing strength. The amount of Mica in sand should not be more than 1°/o.

Size of Sand.

The effect of the size of sand on he strength of mortar is very noticeable; several tests were made in the laboratories and will be mentioned under mortar tests and they show clearly that the better graded the sand is the stronger the mortar, other conditions being the same. The well graded sand makes the best mortar, the coarse sand comes second and the fine sand is the last and gives the weakest mortar.

The best way to determine the fineness of sand is by means of sieves which have certain market numbers.

The following table gives the apertures of the sieves used in the laboratory.

Sieve No.	Aperture inch.	Aperture mm.	Sieve No.	Aperture	Wire
7	0.0949	2.411	10	0.076	0.1670
14	0.0474	1.204	18	0.0336	0.853
25	0.0236	0.599	30	0.0197	0.500
52	0.0116	0.295	44	0.0139	0.353
100	0.006	0.152	72	0.0083	0.211

Typical curves for fineness of 5 different kinds of sand are plotted :—

1 — Very fine.

2 — Fine but better graded.

3 — Medium and well graded.

4 — Coarse.

5 — Very coarse.

When the sample submitted is analysed by means of the sets of sieve mentioned above the fineness curve may be plotted against the typical curves shown. Form No. 4015 is a typical sheet for the analyses made of sand in Mohammed Aly' Barrages Laboratory. The typical curves are taken from these given by Mr. F. E. Turneature and Mr. Johnson and they serve our purpose very well.

The Organic Matter; is tested by means of the addition of hydrochloric acid (diluted 1 ; 3). The sand is put in a beaker with a filter paper and washed thoroughly with the acid. The sand and filter paper is then put in an oven to be dried. The filter paper is then burnt and the weight of ashes added to the weight of sand and compared to the original weight of sand tested to give the amount of organic matter existing.

Specific Gravity :

Two methods are used :—

(a) A certain quantity of water is put in a measuring glass (say V cm3) and a certain amount of sand which has been previously thoroughly dried and weighed (let the weight be W in grams) is added slowly to the water and the final vol. V^1 cm^3 noted.

$$\text{Specific gravity} = \frac{W}{V^1 - V} = S$$

Remarks: The sand should be added to the water slowly. Avoid putting sand in measuring glass first and adding water afterwards, as the water cannot expel the air from the voids in the sand.

(b) By getting the weight of a specimen in the air and its weight while submerged in water.

Percentage of Voids.

Weigh some sand W grms. Put them in a measuring glass and shake well and determine the volume when dry = v cm^3. Get the specific gravity and let it be S. Also P = percentage of voids.

$$\text{the real vol. of sand} = \frac{W}{S}$$

$$\text{also ditto.} \quad = v - \frac{P}{100} v$$

$$\frac{W}{S} = v - \frac{P}{100} v$$

$$P = 100 \left(1 - \frac{W}{S\,v}\right)$$ which determines the percentage required.

A Second Method.

Another easier method is to determine the volume displaced by the sand which is equal to $V^1 - V$ (see specific gravity). Get the volume (the apparent vol.) of the same quantity when dry = Va.

$$\text{then } P = \frac{Va - (V_1^1 - V)}{V\,a} \times 100$$

Effect of Moisture.

The moisture increases the bulk of sand and care should be taken regarding this when proportioning the concrete or mortar.

Voids in Sand.

1 — Fine sand contains a greater percentage of voids than coarse sands.

2 — If the grains of sand are all equal in size and shape the percentage of voids will be the largest.

M. A. B
G. 4015

قناطر محمد علي

MOHAMMAD ALY BARRAGES

معمل اختبار المواد

LABORATORY OF TESTING SAMPLES OF MATERIALS

L.A.B. Nº

DATE التاريخ

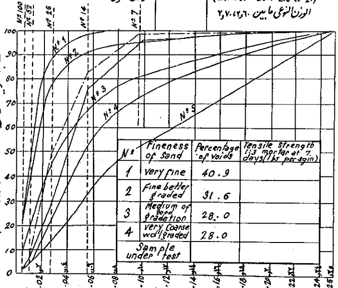
تحليل عينات الرمل
SAND REPORT

Sample submitted by		عينة واردة من
Date and reference Nº		تاريخ الورود والنمرة
purpose of which required		الاستعمال

TEST	RESULT	REMARKS
Chemical Composition Loss of wei on extraction with hydraulic acid الفاقد بعد استعمال حمض الهيدروكلوريك		No more than 0.50 grm لا يزيد عن ٥٠ جرام
SPECIFIC WEIGHT الوزن النوعي		Should be more than 2.6 (normal bet. 2.6 & 2.7 الوزن النوعي ما بين ٢٫٦ و ٢٫٧

درجة النعومة
FINENESS

Seive Nº	Residue	نمرة المنخل	
1/8"	1.955	"١/٨	
Nº 7	1.358	نمرة ٧	
Nº 14	21.008	نمرة ١٤	
Nº 25	48.675	نمرة ٢٥	
Nº 52	21.014	نمرة ٥٢	
Nº 100	5.381	نمرة ١٠٠	
	0.610		



Nº	Fineness of Sand	Percentage of voids	Tensile Strength 1:3 mortar at 7 days (lbs per sq in)
1	very fine	40.9	
2	Fine better graded	31.6	
3	Medium of good gradation	28.0	
4	very Coarse well graded	28.0	
Sample under test			

APERTURE OF SIEVES IN INCHES ——— سعة عيون المناخل بالبوصة

REMARKS ——— ملحوظات

المهندس المقيم
RESIDENT ENGINEER

3 — Materials with round particles contain less voids than materials of angular form. The former fit each other in a better way.

4 — For best results, sand for mortar requires more fine materials than sand for concrete.

5 — For maximum watertightness, mortar or concrete may require a slightly larger proportion of fine grains in the sand than for maximum density or strength. For maximum density and strength coarse sand is better.

MORTAR.

Tensile Stresses.

All tensile stresses on mortar are done with the standard sand except some of the special research tests. The average stress after three days is above 300 lbs / in².

EFFECT OF SIZE OF SAND

Cement Consignment No 43 BIRKASH SAND 8.1% of Water "Weight"

TENSION TEST.

3 : 1 MORTAR BY WEIGHT.

Mortar made in the lab. and beated down with standard spatula

Sand passed from 1/8" and retained on Sieve No. 10 Date of Gauging 22.8.37 Marked with (9.43)						Sand passed from Sieve No. 10 and retained on Sieve No. 20 Date of Gauging 24.8.37 Marked with (10-43)					
3d.	7d.	28d.	3Ms.	6Ms.	1 Year	3d.	7d.	28d.	3Ms.	6Ms.	1 Year
540	630	640	650	590	740	460	520	550	530	530	630
520	550	640	560	560	640	460	470	550	520	510	610
490	530	620	550	500	640	450	460	550	490	510	610
420	500	590	520	480	650	430	450	480	480	480	590
380	450	550	460	450	620	400	450	460	460	470	590
380	450	480	450	450	620	400	400	400	460	430	540
455	518	587	532	505	652	433	458	492	490	488	595

Sand passed from Sieve No. 30 Date of gauging 26.8.37 Marked (11 - 43)						Sand passed from sieve 1/8" (Natural Sand) Date of Gauging 28.8.37 - Marked (12.43).					
3d.	7d.	28d.	3Ms.	6Ms.	1 Year	3d.	7d.	28d.	3Ms.	6Ms.	1 Year
400	410	500	500	530	610	500	550	640	680	630	640
390	410	480	490	490	600	500	530	640	630	600	630
390	400	470	480	490	580	490	520	640	620	600	630
360	370	430	470	420	580	490	520	560	600	550	590
340	370	420	430	420	550	470	520	550	500	550	590
330	370	420	420	350	550	460	520	530	550	550	590
368	388	453	465	450	578	485	527	593	613	580	612

EFFECT OF SIZE OF SAND

TENSION TEST

3 : 1 MORTAR BY WEIGHT.

STANDARD SAND Date of Gauging 30.8.37 Marked (13.43.)						Sand passed from sieve No. 30 Date of Gauging 6 9.37 Marked (14.43) 8.6 % of Water					
3d.	7d.	28d.	3Ms.	6Ms.	1 Year	3d.	7d.	28d.	3Ms.	6Ms.	1 Year
570	600	610	680	570	550	370	430	450	580	550	550
530	600	580	670	550	550	360	420	450	550	520	650
530	580	580	670	550	530	320	370	440	510	460	640
510	570	570	660	530	510	340	340	440	510	450	600
510	560	560	650	500	510	310	330	370	500	450	600
500	550	560	650	480	510	290	330	370	500	420	600
525	577	577	663	530	527	322	370	420	525	475	623

MOHAMMAD ALY BARRAGES

CEMENT REPORTS.

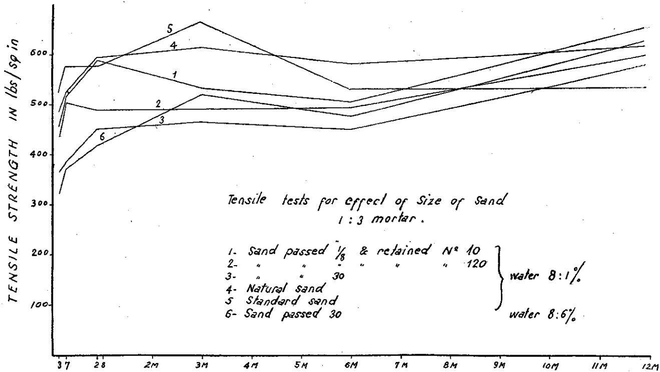
CONSIGNMENT Nº	65 Tura.		66 Tura		67 Tura		68 Tura		69 Tura		70 Tura		71 Tura		72 Tura		73 Helwan		74 Helwan	
TEST	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH	BARRAGE	TOURAH
Date of grinding gauging	21-7-37	5-7-37 5-7-37	1-8-37	6-7-37 6-7-37	31-7-37	7-7-37 2-7-37	2.8.37	8-7-37 8-7-37	9.8.37	9-7-37 9-7-37	15.11-37	13.10.37 13.10.37	17.11.37	14.10.37 14.10.37	18.11.37	14.10.37 14.10.37	16.11.37	9.6.37 11.6.37	21.11.37	8.6.37 8.6.37
FINENESS Residue on sieve of B.S. Mesh Nº 70 - 10%	9.7	8.0	9.5	8.7	8.9	8.2	10	7.10	10	8.60	9.5	5.6	7.1	6.6	8.0	7.30	6.7	4.0	7.5	7.8
" " " " " " 72 - 1%	0.1	0.2	0.12	0.2	0.1	0.2	0.15	0.10	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.20	0.2	0.2	0.5	0.70
SETTING TIME Initial .. 30 minutes (minimum)	115	100	95	105	103	110	84	100	75	95	95	90	90	100	90	110	95	80	85	100
Final .. 10 hours (maximum)	3-15	2-45	2-45	3-05	2-53	2-55	2-0	2-50	3-20	2-45	3-15	2-40	3-05	2-55	3-15	3-00	3-20	2-15	3.15	2-45
SOUNDNESS To expand not more than 10 m.m. nor more than 5 m.m. after 7 days aeration if previous test fails	1.5	1.5	1.5	1	1.5	1.50	2	1	2	1	1.5	1.50	1.5	1.50	1.5	1.0	1.5	1.0	2.0	2.0

TENSILE STRENGTH	65 Tura NEAT 7 days	65 SAND 3 days	65 SAND 7 days	66 Tura NEAT 7 days	66 SAND 3 days	66 SAND 7 days	67 Tura NEAT 7 days	67 SAND 3 days	67 SAND 7 days	68 Tura NEAT 7 days	68 SAND 3 days	68 SAND 7 days	69 Tura NEAT 7 days	69 SAND 3 days	69 SAND 7 days
NEAT TESTS (optional test) At 7 days to be not less than 600 lbs. per square inch.	1280	550	570	1240	520	580	1240	570	680	1440	540	590	1180	500	580
SAND TESTS (3 sand : 1 cement)	1250	510	530	1130	500	570	1240	550	650	1350	520	580	1180	500	540
At 3 days to be not less than 300 lbs. per square inch and at 7 days to	1260	510	520	1110	490	540	1220	550	560	1250	520	550	1100	480	500
show an increase over that at 3 days.	1210	500	500	1110	480	500	1150	500	560	1190	510	520	1090	450	500
and to be not less than 375 lbs. per square inch	1200	450	500	1090	480	500	1110	410	550	1180	470	500	1090	390	480
	1190	420	450	1000	440	460	1110	400	550	1060	450	500	1080	380	440
AVERAGE	1230	490	512	1113	485	525	1145	488	592	1245	502	540	1120	450	507
TOURAH RESULTS	1210	503	528	1269	496	567	1166	495	554	1307	511	539	1289	503	546

TENSILE STRENGTH	70 Tura NEAT 7 days	70 SAND 3 days	70 SAND 7 days	71 Tura NEAT 7 days	71 SAND 3 days	71 SAND 7 days	72 Tura NEAT 7 days	72 SAND 3 days	72 SAND 7 days	73 Helwan NEAT 7 days	73 SAND 3 days	73 SAND 7 days	74 Helwan NEAT 7 days	74 SAND 3 days	74 SAND 7 days
	1500	470	480	1430	480	490	1540	420	500	1470	450	500	1540	430	500
	1460	470	470	1430	470	490	1520	420	440	1430	430	500	1490	425	500
	1390	440	460	1430	450	490	1500	400	500	1360	420	470	1450	420	470
	1360	410	435	1250	440	470	1400	400	440	1320	410	450	1430	410	450
	1330	400	415	1210	440	440	1360	380	430	1300	400	450	1430	400	430
	1300	400	410	1140	400	430	1230	360	430	1300	400	430	1280	400	500
AVERAGE	1390	433	445	1315	447	468	1425	397	457	1363	418	467	1437	414	475
TOURAH RESULTS	1157	505	538	1253	474	555	1233	500	570	1258	522	543	1226	447	503

CONSIGNMENT Nº	65 Tura.		66 Tura		67 Tura		68 Tura		69 Tura		70 Tura		71 Tura		72 Tura		73 Helwan		74 Helwan	
PAT Immersed in cold water for seven days.	GOOD		GOOD		GOOD		GOOD		GOOD		GOOD		GOOD		GOOD		GOOD		GOOD	
Colour in air	"		"		"		"		"		"		"		"		"		"	
" " water	"		"		"		"		"		"		"		"		"		"	
PERCENTAGE OF WATER Percentage of water required to give a standard penetration of 5 to 7 m.m. from bottom of Vic at mould	27	28.2	27.5	28.2	27	28.2	27.5	28.2	27	28.2	27	28.2	27	28.2	26.5	28.2	26	28.2	26	27.5
percentage of water required to give a paste of normal consistency	21.1	22.0	21.5	22.0	21.1	22.0	21.5	22.0	21.1	22.0	21.1	22.0	21.1	22.0	20.7	22.0	20.3	22.0	20.3	21.5
percentage of water used in gauging sand briquettes	7.8	8.0	7.9	8.0	7.8	8.0	7.9	8.0	7.8	8.0	7.8	8.0	7.8	8.0	7.7	8.0	7.6	8.0	7.6	7.9

REMARKS


TENSILE STRENGTH IN lbs/sq in
600
500
400
300
200
100
3
7
28
2M
3M
4M
5M
6M
7M
8M
9M
10M
11M
12M
1
2
3
4
5
6
Tensile tests for effect of Size of Sand
1 : 3 mortar.
1- Sand passed 1/8" & retained Nº 10
2- " " " " " " 120
3- " " 30
4- Natural sand
5 Standard sand
6- Sand passed 30
water 8:1%
water 8:6%

EFFECT OF SIZE OF SAND TEST IN COMPRESSION

3:1 Mortar by Weight

Laboratory test, Cubes beaten down with the spatula

Cement Cons. № 43
Birkash sand

percentage of Water	SIZE OF SAND	STRESS IN POUNDS per □"				Wt of m³/ Kgs.	REMARKS.
		28 day test	3m^s Test.	6 Months Test	1 Year test		
8.1%	Sand passed from sieve 1/8"	5010	6433	7290	7518	2361	
8.1%	Sand passed from sieve 1/8" and retained on № 10	6269	7198	6928	7676	2408	
8.1%	Sand passed from sieve № 10 and retained on № 20	5319	6390	6194	6402	2375	
8.1%	Sand passed from sieve № 30	2908	3898	3718	4279	2245	
9.1%	Sand passed from sieve № 30	3996	4758	4419	4767	2275	
8.1%	Standard Sand.	6181	6408	5972	7158	2366	

EFFECT OF SIZE OF SAND TEST IN COMPRESSION

3:1 MORTAR BY WEIGHT

Laboratory test, cubes beaten down with the spatuba.

Cement Cons Nº 43
birkash sand
passed from sieve 1/8 and retained on Nº 10
percentage of water 8.1%

Example of one of the tests.

Cons. Nº	Date of gauging	Nº of Cube	Date of testing	AGE	wt. in air grams.	wt. in water grams	Volume C.C.	Area □"	Crushing load Tons.	Stress lbs/□"	Density	wt of lbs/fts	REMARKS.
43	20/9/37	375			875	508	367	8.044	23.2	6391	2.3842	149.0	
"	"	376	18.10.37	28 days	872	510	362	7.935	22.7	6308	2.4088	150.6	
"	"	377			864	505	359	7.869	21.8	6109	2.4345	152.2	
"	"	378			878	515	363	7.957	28	7759	2.4187	151.2	
"	"	379	20.12.37	3 Months	873	509	364	7.979	24	6632	2.3983	149.9	
"	"	380			878	515	363	7.957	26	7205	2.4187	151.2	
"	"	381			879	507	372	8.154	24	6490	2.3253	145.3	
"	"	382	20.3.38	6 Months	870	505	365	8.000	28	7717	2.3835	148.9	
"	"	383			872	505	367	8.044	24	6578	2.3487	146.8	
"	"	384			878	515	363	7.957	30	8313	2.4187	151.2	
"	"	385	20.9.38	1 Year	878	515	363	7.957	26	7205	2.4187	151.2	
"	"	386			872	510	362	7.935	27	7509	2.4088	150.6	

Laboratory Tests on Effect of Size of Sand,

Interesting tests were made in the laboratory to get the effect of the size of the sand in the tensile strength of mortar and six different tests were made for a period of one year for both Birkash sand and standard sand: Birkash sand was sieved to different sizes.

1. Passing 1/8" retained on sieve No. 10.
2. Passing No. 10 retained on sieve No. 20.
3. Passing No. 30.
4. Natural sand excluding with particles above 1/8".
5. Standard sand (passing sieve No. 18 and retained on sieve No. 25.)
9. Same as in 3 but with different percentage of water.

It has been found that fine sand needs more water than coarse sand to get the same consistency. The fine sand has more exposed area and more voids and these reasons explain why it needs more water. Birkash sand needs more water than Khatatba sand because of the fact that it is finer. In No. 3 it was found out that the mortar is too dry for usual workability and a special test was made with a vicat needle with increased percentage of water to get the same penetration of the plunger in sand No. 3 as with natural sand. The percentage of water was found to be 8-6% instead of 8-1% and another tensile test was made with the new percentage. The result is that the stresses given by the second test are lower than the first one; this is owing to the fact that the dry mortar needs a larger number of strokes by the spatula to fill in the mould properly and also to the important fact that there is less water in the mortar, less voids and the more density and strength.

The result of the six tests is that the coarser the sand the better, and well graded sand is the best.

The standard sand gives high stresses at early dates but low stresses afterwards. It should be noted that the standard sand is cleaner.

Another thing to be noticed is that when three months old the fine sand showed slight decrease in strength while the coarse and natural sand was still increasing.

The effect of the size of sand on tension stresses is outlined above and the following will show the effect on crushing stresses.

The tests were made on Birkash sand of different sizes to compare with the tensile stresses beforementioned. Coarse and fine sands were used (not graded), also medium grained natural and standard sands. Percentage of water was the same in all tests except when necessary to obtain normal workability. Cubes of mortar were beaten down with the standard spatula. The result is shown in table No. 8 and diagram No. 10. Also a typical sheet of one of the tests is attached, paper No. 9.

The coarser the sand the better and the fine sand shows low stresses. It was also noticed that the coarse sand is higher in strength than the natural graded sand; this should not be the case as the graded sand has less voids and its mortar is denser The big and abrupt decrease in stress of fine sand when compared with the stress of the coarse sand (the former is 54 °/o of the latter) suggested that there may be some organic material with or covering the grains in the fine sand and may be the cause of the greater fall in stress of the well graded sand than in the coarse one. An experiment was made to determine the percentage of organic and foreign material and confirmed the suggestion. The fine part of the sand contained 1.458°/o of organic materials while the coarse part of the same sand contains 0.736o/°.

The sand, however, contains 1.100 °/o foreign material which is not great and is quite allowable.

However, another experiment made on fine sand but carefully washed before using showed the stress to be a little higher as shown on test No. 6 mentioned in the same table.

Mortar in Compression. Effect of Size of Sand etc.

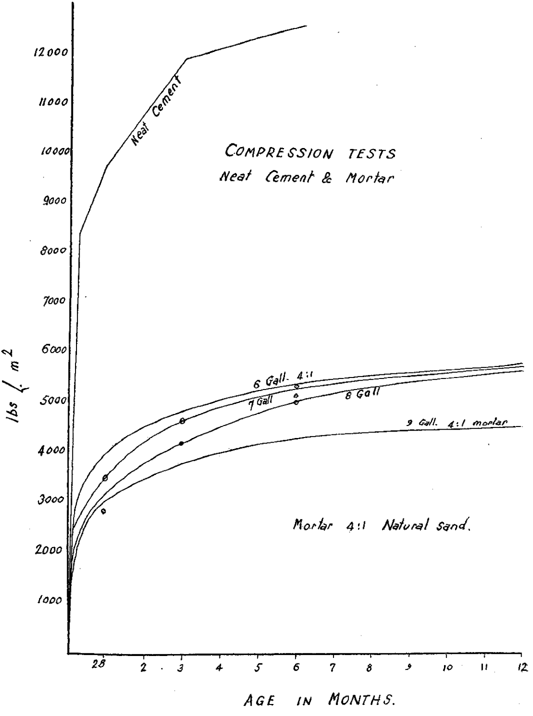
Mortar made in the field for masonry work or pitching is always tested for crushing strength. Samples of mortar are taken when being mixed and moulds are filled on the site and are left in a specially made chamber or box fitted with a watertight bottom and sides and placed on two shelves. The bottom of the chamber is always kept supplied with water, so as when the chamber is closed there will be about 90°/o humidity. Moulds are left for twenty four hours then loosened and the moulded blocks are taken to the laboratory to be water cured for at least twenty days. For long period tests the cubes are cured for 28 days and then kept in the air afterwards till the time of test.

Specimens are taken of each consignment and represent each part of the work. Usually the mixing of mortar is done by hand; but when there is a rush of work or when plenty of mortar is required machine mixers are used. This last method makes it possible and easy to calibrate the percentage of water, which it is otherwise hard to observe and standardise.

Attached is a typical form from the files on mortar tests and shows the results of compression tests on cubes of mortar of different classes as made and used on site.

The average stress for 1:2 mortar is 3800 lbs/in2 after seven days and 5600 lbs/in2 after 28 days. Average crushing stress for 1:1 mortar is 4800 lbs/in2 after seven days and 7800 lbs/ in2 after 28 days. For 1:4 mortar it is 1900 lbs/ in 2 after seven days and 2700 lbs/ in2 after 28 days.

Besides the daily tests made, special long period tests for two years and in some cases for a period of four years will be made to get the behaviour of mortar in compression after a long period.


COMPRESSION TESTS
Neat Cement & Mortar
Neat Cement
6 Gall. 4:1
7 Gall
8 Gall
9 Gall. 4:1 mortar
Mortar 4:1 Natural sand.
lbs/□"
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
28
2
3
4
5
6
7
8
9
10
11
12
AGE IN MONTHS.

قنـــــاطر محمد على

(اختبار الضغط على قوالب المونة)

نمرة رسالة الاسمنت	نمرة القالب	وزن القالب بالكيلو	نسبة المونة	النسبة المئوية للمياه بالوزن	موضع استعمال المونة المأخوذ منها العينة	تاريخ عمل القالب	تاريخ اختبار القالب		نتيجة الاختبار	نتيجة الاختبار	ملحوظات
							المدة	التاريخ	رطل على البوصة المربعة	رطل على البوصة المربعة	
١٩	٢٢	٠,٨٣٠	١:١		كحلة بغلة الهويس الشرقية	٣٧/٥/٢٨	٧ أيام	٣٧/ ٦/ ٤	٤٧٦٠		
١٩	٢٣	٠,٨١٣	١:١		«	٣٧/٥/٢٨	٧ أيام	٣٧/ ٦/ ٤	٤٩٦٤		
١٩	٢٤	٠,٨١٢	١:١		«	٣٧/٥/٢٨	٢٨ يوم	٣٧/ ٦/٢٥	٤٨٦٢	٨١٧٠	
١٩	٢٥	٠,٨١٥	١:١		«	٣٧/٥/٢٨	٢٨ يوم	٣٧/ ٦/٢٥		٧٦٠٠	
٥٠	٢٩١	٨,١٥٦	٢:١		الدستور والثلاثات	٣٧/٧/١٧	٧ أيام	٣٧/ ٧/٢٤	٣٢٨٠	٧٨٨٥	
٥٠	٢٩٢	٨,٢٤٧	٢:١		«	٣٧/٧/١٧	٧ أيام	٣٧/ ٧/٢٤	٤٠٣٠		
٥٠	٢٩٣	٨,١٦٦	٢:١		«	٣٧/٧/١٧	٧ أيام	٣٧/ ٧/٢٤	٤٢٠٠		
٥٠	٢٩٤	٨,٠٩٤	٢:١		«	٣٧/٧/١٧	٢٨ يوم	٣٧/ ٨/١٤	٣٨٣٣	٥٢٥٣	
٥٠	٢٩٥	٨,٢٣٥	٢:١		«	٣٧/٧/١٧	٢٨ يوم	٣٧/ ٨/١٤		٥٤٣٨	
٥٠	٢٩٦	٨,١٩٩	٢:١		«	٣٧/٧/١٧	٢٨ يوم	٣٧/ ٨/١٤		٦١٨٠	
٥٢	٣١٧	٨,٠٨٥	٤:١		التكسية الامامية	٣٧/٧/٢٢	٧ أيام	٣٧/ ٧/٢٩	٢٠١٠	٥٦٢٣	
٥٢	٣١٨	٨,٠٤٨	٤:١		«	٣٧/٧/٢٢	٧ أيام	٣٧/ ٧/٢٩	٢٠٤٠		
٥٢	٣١٩	٨,٢٠٠	٤:١		«	٣٧/٧/٢٢	٧ أيام	٣٧/ ٧/٢٩	١٨٥٠		
٥٢	٣٢٠	٨,٢٠٧	٤:١		«	٣٧/٧/٢٢	٢٨ يوم	٣٧/ ٨/١٩	١٩٦٦	٢٦٥٧	
٥٢	٣٢١	٨,٠٣٧	٤:١		«	٣٧/٧/٢٢	٢٨ يوم	٣٧/ ٨/١٩		٢٥٩٥	
٥٢	٣٢٢	٨,٢٣٢	٤:١		«	٣٧/٧/٢٢	٢٨ يوم	٣٧/ ٨/١٩		٢٨٤٢	
٤٣	١٩٩	٨,١٦٥	٤:١		للتجـــربة	٣٧/٧/ ٧	٢٨ يوم	٣٧/ ٨/ ٤	٢٨٤٢	٢٦٩٨	
٤٣	٢٠٠	٨,٢٠٣	٤:١		«	٣٧/٧/ ٧	٢٨ يوم	٣٧/ ٨/ ٤	٢٩٠٤		
٤٣	٢٠١	٧,٩٣٠	٤:١		«	٣٧/٧/ ٧	٣ شهور	٣٧/١٠/ ٧	٢٨٧٣	٤٠١٧	
٤٣	٢٠٢	٨,٠٣٠	٤:١		«	٣٧/٧/ ٧	٣ شهور	٣٧/١٠/ ٧		٤٣٨٧	
٤٣	٢٠٣	٨,٠٠٧	٤:١		«	٣٧/٧/ ٧	٦ شهور	٣٨/ ١/ ٧	٥٤٣٨	٤١٩٨	
٤٣	٢٠٤	٧,٩٧٧	٤:١		«	٣٧/٧/ ٧	٦ شهور	٣٨/ ١/ ٧	٥٠٦٧		
٤٣	٢٠٥	٧,٩٤٥	٤:١		«	٣٧/٧/ ٧	٩ شهور	٣٨/ ٤/ ٧	٥٢٥٢	٤٥٤١	
٤٣	٢٠٦	٧,٩٩٠	٤:١		«	٣٧/٧/ ٧	٩ شهور	٣٨/ ٤/ ٧		٤٥٤١	
٤٣	٢٠٧	٧,٨٦٠	٤:١		«	٣٧/٧/ ٧	١ سنة	٣٨/ ٧/ ٧	٢٥٦٢		
٤٣	٢٠٨	٧,٩٣١	٤:١		«	٣٧/٧/ ٧	١ سنة	٣٨/ ٧/ ٧	٥٦٤٦		
٤٣	٢٠٩		٤:١		«	٣٧/٧/ ٧	٢ سنة	٣٩/ ٧/ ٧			
٤٣	٢١٠		٤:١		«	٣٧/٧/ ٧	٢ سنة	٣٩/ ٧/ ٧			
٤٣	٢١٠		٤:١		«	٣٧/٧/ ٧	٣ سنة	٤٠/ ٧/ ٧			

Daily tests showed that the class of mortars was made in the right proportion and the method of mixing was always satisfactory.

Regauging Mortar.

One of the problems met with in practice is :—

(a) Mortar is usually made in batches of such quantities that it remains for some time before it is finished with and all used.

(b) Is the strength of the mortar effected if left for some time in the sun and how?

(c) What is the effect of regauging mortar (i.e. adding some water every now and then ?

A series of tests were made to cover these questions. Briquettes for tension t est were taken from fresh mortar, then after forty five minutes, one and a half hours and two and quarter and three hours. In each case samples were taken from mortar before and after regauging. The percentage of water in the mortar is 14.2o/o which is considered the percentage used in practice. The test was made on a sunny day of August and the mortar kept all the time in the sun and uncovered. The result are shown on table p. 234 from which we can see that.

(1) The strength of mortar (if not regauged) when kept in the sun for a long time decreases to about 81o/o of its original strength.

(2) If the mortar is regauged the tensile is not affected appreciably.

(3) If the mortar is left for a time longer than the time required for the final setting of the cement the mortar will be of no use and the stress will decrease suddenly.

The above is the effect on the tension stresses and other experiments are in hand to see the effect on the crushing stresses. Other tests were made on the adhesive strength of regauged mortar as follows :—

Effect of Regauging Mortar on Adhesive Strength.

Cubes of mortar (1:3) were made with 5/8" rods inserted in the middle of each cube. Care was taken to have similiar conditions in all the cubes. The results are as follows :—

(1) Adhesivè stress after 45 min. (regauged) = 31 kg/cm2

(2) Adhesive stress after three hours (regauged) = 18.3 kg/cm^2.

This shows clearly that the effect of regauging gives a stress about 59 o/o of the stress given by mortar. Regauged before setting began.

TENSION TEST FOR REGAUGING MORTAR

CEMENT CONS. No. 43
Birkash Sand

3 : 1 Mortar (by weight)
Mortar made in the lab., and kept in the sun.
Samples were taken at different times without and with regauging.

14.2 % of Water (by weight) used

Samples taken immediately after gauging		Samples taken after ¾ Hour				Samples taken after 1½ Hours				Samples taken after 2¼ Hours				Samples taken after 3 Hours			
Fresh Mortar		Mortar before Regauging		Mortar after Regauging		Without Regauging		With Regauging		Without Regauging		With Regauging		Without Regauging		With Regauging	
Marked 0 - 43		Marked 1 - 43		Marked 2 - 43		Marked 3 - 43		Marked 4 - 43		Marked 5 - 43		Marked 6 - 43		Marked 7 - 43		Marked 8 - 43	
7Ds	6Ms	7Ds	6Ms	7Ds	6Ms	7Ds	6Ms	7Ds	6Ms	7Ds	6Ms	7Ds	6Ms	7Ds	6Ms	7Ds	6Ms
460	590	520	530	460	500	440	360	480	480	400	460	440	430	—	410	480	470
460	450	420	450	420	480	430	350	440	470	360	420	370	420	380	370	460	350
420	450	360	410	400	450	380	350	360	450	350	350	250	390	370	330	400	320
420	420	300	390	—	430	350	320	350	450	330	310	300	350	300	300	370	270
410	420	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
410	380	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
430	452	400	445	426	465	400	345	407	463	360	385	360	398	350	352	427	352

Coarse Aggregates.

Coarse aggregate makes the largest portion of the concrete and "it consists of crushed stones, gravel or other approved inert materials with similar characteristics or combination thereof, clean, hard, strong, durable, uncoated with particles of alkali organic or other deleterious matter".

Granite crushed to (grey rock) were used in Aswan Dam Second Heightening for ordinary and reinforced concrete work with excellent results.

Also limestone crushed to graded aggregate is suitable for making concrete, but it is advisable not to use such concrete in water works due to the liability of the limestone dissolving in water.

Gravel, ballast and crushed ballast all make excellent aggregates for concreting, providing that they fill the above mentioned coditions and be well graded.

Very wide researches are made for the determination of the effect of size and the grading of the aggregates on the strength density, permeability and other properties of concrete.

All concretes (plain and reinforced) are designed on the assumption that for each certain class of concrete, there is a definite strength and uniform quality. In our present specification classes of concrete are stated and stresses are fixed.

Several methods, about five in number, are generally adopted," each aiming to determine the proportions of the several ingredients that result in a mass containing the maximum amount of solid matter per unit volume".

Another method now widely used in America (U.S.A.) is made by the noted professor Abrams, who advanced the "Water Ratio Theory".

(1) The first method is the proportioning by Arbitrary volumes: as to say the concrete should be 1:2:4 or 1:3:6 etc. The strength of a ratio of 1:2:4 is taken as 2000 lbs/ins ultimate crushing stress on 28 days test. This, however, varies considerably depending mainly on the type of grading of ingredients and of water percentage. The designs usually are liberal and the factor of safety allows the concrete to fulfil its mission, although its strength is below the mentioned stress. Real economy can be obtained by means of better knowledge of proportioning.

(2) Proportioning by voids: The voids can be determined by one of either methods described for sand. The theory is based on the assumption that the sand fills in the voids of the Ballast and the cement fills in the voids of the sand. This happens only in theory as in practice the sand comes in between the ingredients of the coarse aggregates pushing the particles away and thus necessitating more percentage of sand. Also it does not take into account the effect of bulking of sand and the volume of water.

(3) Water cement ratio: This is widely adopted now in the U.S.A. but not on the Continent. It states that "with given concrete materials and conditions of test, the quantity of mixing water used determines the strength of the concrete, so long as the mixture is of a workable plasticity".

The equation expressing this relation was found to be for average conditions.

$$S = \frac{140000}{7x}.$$

Where S = compressive strength of concrete at 28 days.

$$x = \text{water ratio} = \frac{\text{vol. of mixing water}}{\text{vol. of cement.}}$$

If rigid control is lacking the concrete may be expected to be weaker as expressed by

$$S = \frac{140000}{9x}$$

In all the above mixes the concrete must be of workable consistency and the sand should not be more than 50% and not less than 33% of the Ballast in volume.

(4) Mechanical Analysis: This is also a widely known method and in the writer's opinion is one of the direct, effective methods. It is adopted in Mohammed Aly Barrages work for different reasons. Percentages of different sizes are given in the contract specifications. Thus a curve could be drawn which takes place of Fuller's curve concerning this theory. Any deviation from the standard given specification can at once be checked and put right. The specified percentages are already mentioned in the first part and they give the proportions of the ballast. The sand is given only as ½ in volume of the ballast and no mention is made of the grading of the sand; Professor Fuller combined the two curves together and found that the best curve which gives best results is a combination of a straight line and a part of an ellipse; the material of which makes the densest concrete.

Attached herewith a diagram showing the typical analysis of ballast in our laboratories No. 12 and 13 and another diagram showing the ideal curve of Fuller together with the specified curve in our contract No. 14.

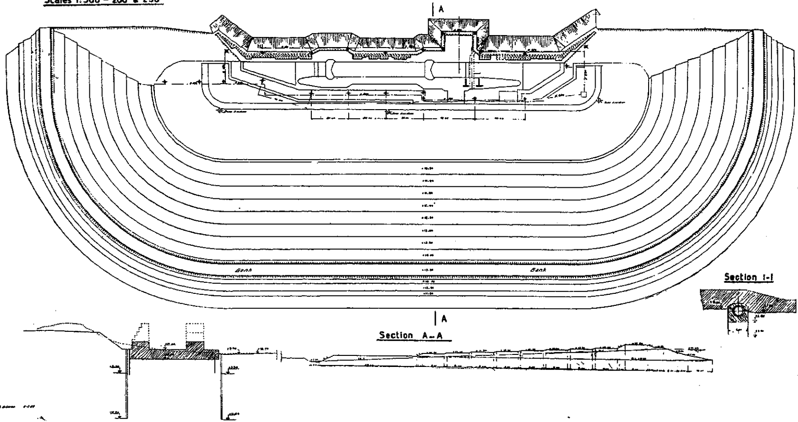
MOHAMMAD ALY BARRAGES — ROSETTA BARRAGE

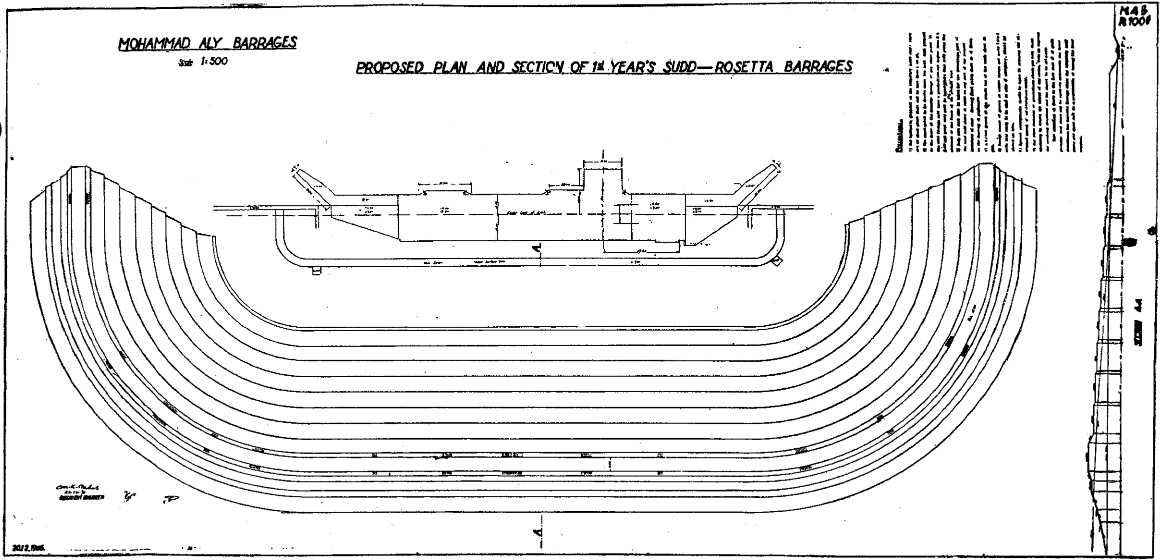
Drawing N° 89

FIRST SEASON

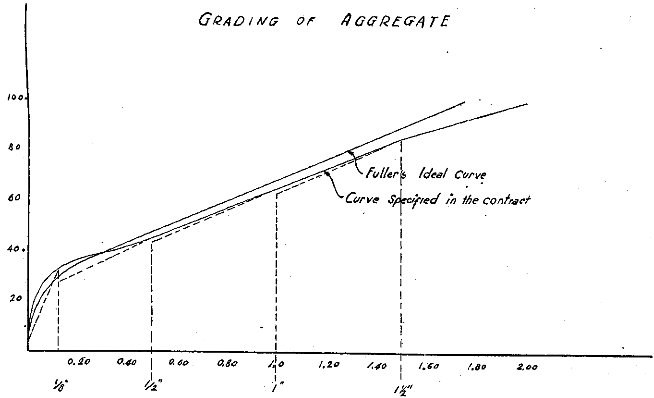
DEWATERING BY WELLPOINT — PUMPING

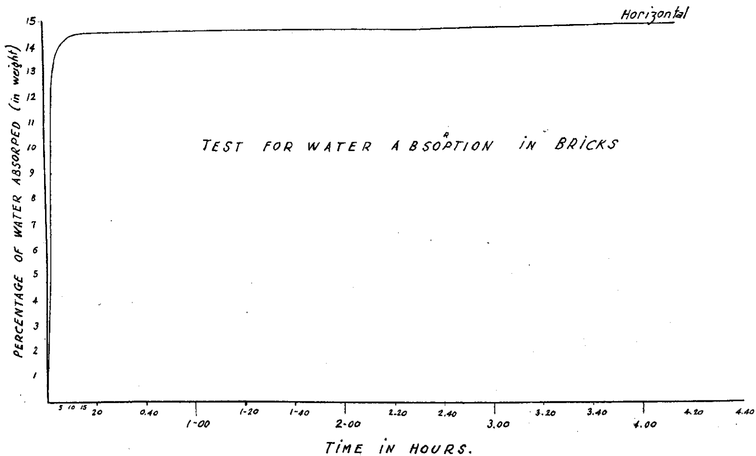
Scales 1:500 - 200 & 250




MOHAMMAD ALY BARRAGES
Scale 1:500
PROPOSED PLAN AND SECTION OF 1st YEAR'S SUDD—ROSETTA BARRAGES
A
A
RESIDENT ENGINEER
20.12.1945.
M.A.B.
R.1001

GRADING OF AGGREGATE




TEST FOR WATER ABSORPTION IN BRICKS
Horizontal
PERCENTAGE OF WATER ABSORPED (in weight)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
5 10 15 20
0.40
1-00
1-20
1-40
2-00
2.20
2.40
3.00
3.20
3.40
4.00
4.20
4.40
TIME IN HOURS.

B R I C K S.

Tests.

The habit of testing the soundness of a brick by knocking two bricks together is a good test for the brick. Clear sound and a metallic ring indicate that the brick is of hard material, well burned and sound.

The absorption should be about one eighth of the original weight and the brick should carry safely a minimum crushing strength of 100 kgs/sq. cm., this value being the average results obtained on six samples selected on site and tested flatwise (E. S. R. specifications).

The bricks when tested should have their surfaces perfectly paralled and smooth: this can be attained by levelling the surfaces with plaster of paris, but in this laboratory this was made by two thin layers of mortar of 1:3 with standard sand. This is a point which should not be omitted.

The brick has greater crushing strength flatwise than edgewise. A wire cut brick has a stress af 130 kg/cm2 flatwise and 75 kg/cm2 edgewise.

Attached table shows the typical way adopted for testing bricks.

Absorption Period.

It is often a matter of discussion in practice as how long the bricks should be kept immersed in water before use. Some specifications call for six hours, others call for twelve hours. To get the right period, absorption curves are made for different kinds of bricks and the absorption per cent is taken every five minutes. The attached curve is a typical one and shows clearly that practically the maximum absorption occurs after about half an hour.

Bricks are soaked in water for one hour and then taken out of water and kept in shade for twelve hours. The absorption in the first case is found to be 15.2% and in the second 14.3% i.e. the loss in absorption after twelve hours in shade is 0.9% which is negligible.

TESTING MATERIALS LABORATORY.

Mohammed Aly Barrages.

King of Materials: Bricks (Burnt Clay).

No. Purpose of Using	Date of Test.	Absorption Test After 24 Hours		Sound	Flatwise Sect. Area cm2.	LOADS			REMARKS
		Actual	Min. Allowable			Actual kgs.	Calculated to kg./cm2	Allowed kg./cm2	
No. 1) SURNAGA BRICKS TEWFIKI REGULATOR	24/11/37	19.75	12.5%	Dull	253	19200	75.90	100	1) Edge broken 2) Shape distorted. 3) Dimensions 23 x 11 x 6.9 cms.
No. 2) KABESH BRICKS TEWFIKI REGULATOR	24/11/37	16.35	12.5%	Dull	300	25500	85.00	100	1) Edge broken. 2) Shape distorted. 3) Dimensions 25 x 12 x 6 cms.

LIMESTONE & SANDSTONE

Limistone consists chiefly of calcium carbonate with small portions of silica, magnesium carbonate, iron, and clay, and are stratified or orlitic in structure (Mitchell),

The most durable kind of limestone is the one that contains calcium carbonate and magnesium carbonate in a crystalline condition.

Alabaster is a kind of limestone consisting of gypsum or calcium sulphate in a crystalline condition.

The E.S.R. Specifications state that " Rubble limestone shall be hard, durable, free from all drys, flaws of any kind, soft or sandy parts and of such a character as to withstand properly the action of the weather as well as the wear of water in submerged structures. Stones shall have sharp edges on all their sides and a minimum volume of 0.01 m3. For pitching, the stones shall have a volume between 0.02 &0.03 m3 at least. Samples of limestone shall be submitted to the approval of the administration. They shall weigh at least 2400 kgs. per cubic metre and have a minimum crushing strength of 1000 kgs/sq. cm for ashlar masonry stones and half this volume for rubble masonry stones. The absorption of water per cent of dry weight must be less than 1 and 3 respectively after 24 hours immersion.

Tests are made here on ashlar limestone on existing structure of Tewfiki Regulator and also for new stones to be used in reconditioning and results are tabulated in attached paper.

Ashlar limestone should be marked for the natural bed of the stone, so as to be built on the same bed as it was in nature.

TESTING MATERIALS LABORATORY.

King of Material : Limestone.

No. of Specimen	Purpose of Using	Date of Test	Absorption Test		Sp. Gr.	Sound	Sectional area cm2.	Max. Load		REMARKS.
			Time	Percentage				Actual	Calculated Kgs.	
9 L	See Remarks	6/11/37	24 hours	8.5	2.10	Good	71.28	17.000	cms.2 238.5	
11 L	Reconditioning existing Works	20/11/37	24 hours	5.20	2.29	Good	72.25	41.500	574.3	Taken from Tewfiki Regulator structure.
12 L	»	»	»	5.30	2.27	»	102.50	49.500	482.9	
13 L	»	»	»	5.30	2.24	»	104.04	56.500	538.2	
14 L	»	»	»	4.80	2.31	»	104.04	52.100	500.0	
3 L	Rubble for Pitching	2/6/37	»	2.74	2.26	Good	No compression test required.			
5 L	»	2/6/37	»	1.50	2.48	»				

Notes : 1.— Care is taken to eliminate the moisture in the specimen before absorption test.

2.— For compression test two opposite sides were made smooth and parallel.

GRANITE IN EGYPT

Geological introduction.

Granite is an igneous rock of volcanic origin and acid composition having 66% of Silicon oxide. It consists of 35% Quartz 52% Orthoclase 10% Mica & 3% Hornblende.

Quartz.

It is called in Arabic Almarro and is silicon Oxide. The crystals of which are shaped hexagonal prisms with two pyramids on the ends. The stone does not cleave but is easy to break; Factor of hardness is 7, and specific gravity 2.65. It is transparent and without colour. It stands heat and acids and is found abundantly all over the world in special crystaline state.

When very pure, it is used as lenses for high power magnifying glasses and it sometimes contains minerals like gold.

Orthoclase. It is the main composition of felspar and consists of silicate of aluminium and silicate of potassium. It crystalises in the monoclinic system and cleaves easily. Factor of hardness 6., S. G. 2.50, colour white, pink or grey and it may often be transparent.

Mica.

Aluminium Silicate with Potassium Oxide and Magnesium. It crystalises in the monoclinic system and cleaves in transparent layers. Colour white or black. Factor of hardness 2.50, S.G. 2.90, shines like glass and sometimes replaces glass owing to its transparency and withstanding of heat.

Hornblende.

Silicate of Magnesium & calcium and iron with little Aluminium. Crystalises in the monoclinic system and cleaves in two complete planes parallel to the sides of the prism. Hardness 5.50, S.G. 3.0, colour dark greenish.

All parts in granite crystalise, but owing to the interference of the different particles together, the crystalisation does not take its natural complete shape. Granite may be coarse or fine grained according to the crystals whether they are big or small. The colour of granite depends upon the colour of the orthoclase of which it is composed.

Granite is one of the fundamental stones and is often found as a core in most of the mountains. In Egypt it exists in the mountains between the Nile valley and the Red Sea, in the desert and at Aswan.

In Upper Egypt, it is found in the Southern parts of the eastern & western deserts and owynate Mountains.

Weather action disintegrates the granite stone into chips and into grains. Mica, Orthoclase and Hornblende turn to silt and clay, which may be carried away with water and aid the fertilisation of cultivable lands. Quartz becomes small grains varying in size and rounded in shape forming the gravel and sands which cover the surface of deserts.

The best kind of granite is the rose (pink) granite rocks which form the first cataract of the Nile at Aswan and the hilly rocks on the sides. Owing to its hardness its nice colour and good polish, the ancient Egyptians used in extensively in their, monuments and sculptures many of which are now scattered all over the world.

In recent years it has been used in the Aswan Dam and the two successive heightenings. It was also used in Nag Hamadi and Assiut Barrages, Kasr-el-Nil Bridge Saad Zagloul statue and other monuments and is now being employed in the Mohammed Aly Barrages.

The Grey Rock, which is a fine grained granite, is used in paving curbstones. It was also used in Aswan Dam. Had it not been for the great distance between Aswan and central Egypt, granite would have been more widely used in structures and buildings.

The granite now being used at Mohammed Aly Barrages is the pink rock type which is coarse-grained. It is quarried to the east of Aswan Dam in the vicinity of the civil Aerodrome.

Quarrying.

Granite is one of the hardest of stones. Its specific gravity ia 265. Its crushing stress is about 1000 kgs/cm^2.

The Guarrying and working of granite needs great skill and practice which few nations have attained as the Italians and the Germans. Ancient Egyptians were masters of this art in their early days, but for reasons which we need not go into this art has been neglected in Egypt. However, the Ministry of Public Works has used granite in the bigger structures of the irrigation works and this has led to a revival in the art. The second heightening of Aswan Dam started with but very few Egyptians who knew very little about working granite, and now in the Mohammed Aly Barrages six hundred Egyptian labourers are working in the Quarries. The time will come when it will not be necessary to call in foreign labour.

Granite, being an igneous rock is supposed not to have any cleaving surfaces. In practice there are three "Ways" or surfaces in which the rock can be easily cleaved. These "ways" are lacated in the plane where the crystals of Orthoclase exist. This explains the cause of existence of three planes of cleaving; the orthoclase crystal being among the class of the monoclonic system which cleaves in three planes.

When the granite is cut in a plane not parallel to the said ways it needs more effort and the surfaces will not be uniform and will be hard to polish.

Ancient Egyptians knew this practice and adopted it in all their works and it should be mentioned that they must have used iron or annealed copper and used it in the granite. The method they adopted was to make V grooves in the rock 5 cms deep, 10 cms long and 2.5 cms wide at the top, spaced ten cms apart in a plane parallel to the way of the stone. Steel wedges were then inserted in the grooves and hammered continuously till the stone cracked. It is said that they used timber wedges in place of steel ones and they used to pour water on them so as to expand and break the stone by force of expansion. This is probably only a story as granite cannot be quarried by such methods.

The method mentioned for cutting stones by means of V grooves needs much effort and time and blasting is used nowadays in quarrying big rocks.

The blasting method has saved a lot of wasted effort and money. Deep holes are made in a perpendicular direction to the "way" of the stone. The hole goes to the depth to which rock is to be split and the requisite amount of gun — powder or other explosive put in, covered with sand, and fired by a fuse. Sometimes numerous charges in a line of drilled holes are exploded simultaneously by means of electricity.

Coarse gunpowder is the explosive ordinarily used, since the quick acting explosives have a tendency to shatter the stone in all directions and break it in many pieces. The black gunpowder is the one commonly used and its chemical composition is 75 % (sodium Nitrate and Potassium Azotate), 13 % Coal and 12 % (Sulpher). It is black in colour and used in cutting small stones since its action is not destructive,

The quick acting explosives used are :

Gelignite No. 1; its chemical composition is 62 % Nitroglycerine, 19 % Potassium Nitrate 19 % cotton saturated with Nitrate. It is made in cylindrical shapes 10 cms long and 7/8" diameter and is yellow in colour and pasty. It is a powerful explosive compared with the black powder mentioned above, 112.25, and hence it is used for blasting stones only.

Detonators used consist of small pots of copper filled with Mercury Felimanite. The fuses are inserted in the mercury and then the pot closed from the top by pressing. This forms one of the most quick acting explosives.

The quantity of powder used depends upon the bulk of the stones to be fractured. Sometimes a space is left at bottom of the holes with tiny pieces of wood. The quantity of powder required can be determined thus.

$$Q = \frac{L^2 \times H}{S}$$

were Q = weight of powder in kgs.

S = a factor depending on kind of rock.
For Aswan granite this factor is equal to 3.5.

L = Distance from side face of the quarry to the line of holes (thickness).

H = Depth of holes of the depth to which the rock is to be split.

The fractured stones are then taken to be cut in turn into smaller pieces for working. Small rounded holes are drilled by hand to a depth of 5 cms and dia. 7/8", and spaced five cms apart in a line parallel to the way of the stones or perpendicular to it. Special plugs rectangular in form at the bottom and rounded at top are then inserted in the holes and driven hard down all at the same time till the stone breaks.

The approximate required dimensions of the stone are given to stone cutters and special templates are then made for the final dressing to the required shape.

Granite is worked in three different ways: The fine picked, the fair picked and the rough picked, each described in the contract specifications in a very clear way.

The tools used are the plug for breaking the stones, the pick for dressing the sides of the stone, the chisel for making the drafts on edges of stone, the axe for dressing the curved parts and bearing surfaces and hammers.

Great attention was given to the kind of rock and the nature of the different kinds as specified. The layout of the quarry is also an important factor so as to be able to use efficiently and properly.

Stones after being properly dressed are checked for dimensions and quality and given certain marks and loaded in railway trucks to be sent to the Delta Barrages. They are carefully protected by timber etc....

The labourers in the quarry are of two classes the getters and the dressers. The former are those who cut the stones and the latter are those who dress them. They work in gangs and get paid according to the output of the squared surface of dressed sides of the stones. A square metre of the fine picked is worth P.T. 210, the fair picked P.T. 150 and the rough picked P.T. 100 and this includes working the beds and sides.

The getters are paid P.T 70 each daily and their Rais is responsible for their pay. The Rais charges P.T. 120 for each square metre supplied. This covers all the expenses of labour, tools, powders, coal, etc.

The steel used in making tools employed in the work is hard swedish steel. Each dresser needs 20 points ready for his own use. The length of each pick is 20 cms and needs to be recharpened every five minutes and reannealed. This is done by a blacksmith who is paid about P.T. 35 a day.

It is easy for an average stone cutter to get an output which is worth P.T. 100 a day.

A gang of 50 dressers can do 400 m^2 a month of rough picked stones at L.E. 400.

All the exposed surfaces in Mohammed Aly Barrages will be in granite and will employ about 200 Italians, 500 Egyptians, 100 Soudanese and more than 1000 "getters" and other labourers. The total cost or the granite which will be supplied to the Barrages is half a million pounds excluding the cost of transport which amounts to L.E. 50,000 Mines Taxes which amounts to L.E. 2500 and the cost of buildings, etc. on site.

Also 10000 m^3 of crushed granite will be supplied for use in the concrete of the arches.

The Ministry of Education made an agreement with the contractors of the Granite to train a number of men, graduates of the Industrial Schools and their teachers.

They approximate to 20 °/o of the Italians employed and will work without pay for one year when they will undergo a practical examination and those who pass will be paid full wages.

On the 22nd of January 1938, the writer was appointed by a Royal Decree to fill the post of "The Inspector General of Irrigation, Lower Egypt", thus terminating his services in the Construction of the Mohammed Aly Barrages as described in this report. He was succeeded by Mahmoud Mohammed Karara Bey

RESIDENT ENGINEER
MOHAMMED ALY BARRAGES.

MOHAMMED ALY BARRAGES

This report is divided up as follows :—

Design
Adjudication
Temporary Works
Permanent Works

As the permanent works are composed of the two main Barrages Damietta and Rosetta as well as other subsidiary works, the description of the former is divided into seasonal works for the locks and Barrages separately while each of the subsidiary works is described individually as it was constructed when found most convenient.

DESIGN.

1. Historical

To make use of the extra stored water after the completion of the 2nd Heightening of Aswan Dam and the construction of Gebel Aulia Dam and to cope with the demands of the increased areas reclaimed in Lower Egypt by feeding the main canals - El Rayahs - with higher levels specially during the sharaki period, July, it has been decided to construct a new barrage between the present Delta Barrage and the subsidiary weirs.

An extensive survey of the Delta Barrage was made to investigate its condition, and as a result of its poor foundation and the uncertainty of standing the increased head — as ascertained by borings through the piers — it was inadvisable to strengthen the structure.

The four to one rule adopted for regulation at the beginning of the flood — during the critical period—namely raising the D.S. water levels by four cms. against every cm. rise in the U.S. levels, is a big source of loss as it passes millions of cubic metres to the sea through the branches to waste.

2. Hydrauric Data

The maximum flood level D.S. the existing barrages have been assumed to be R.L. 18.60 as in the year 1878, and safety has been taken as R.L. 18.80 in designing the new Barrage. The maximum discharge during the flood is one milliard M3/day and is divided between the two branches as follows :—

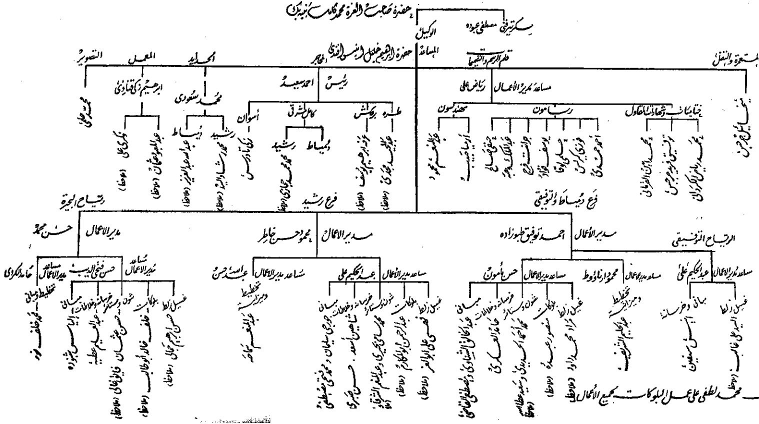
Rosetta Branch	650 Millions M3/day
Damietta Branch........................	350 » »

توزيع العمل

بين حضرات الموظفين الفنيين لقناطر محمد علي

المهندس المقيم

حضرة صاحب العزة محمد كامل نبيه بك



ملحوظة : يشرف محمد لطفي على عمل البلوكات بجميع الأعمال

المهندس المقيم
امضاء
محمد كامل نبيه

The floor level and the number of vents in each branch has been arranged accordingly, but in the case of Damietta the arrea of the water way has been increased to avoid concentrating the intensity of the water flow in the eastern side of the weir if it had been designed to the exact number of sluices to pass the required discharge.

The following table gives a comparison between the old and new Barrages:—

Name of Regulator	No. of Vents		R.L. of Sills		Width of Sluices in mtrs.		Area of Water way M2 at R.L. 19.00			Locks	Old	Weir	New
	Old	New	Old	New	Old	New	Old	New Designed	New Actual				
Damietta	51	34	Varying 9.70 10.20	12.00	2@ 5.5 49@ 5.00	8.00	2376	1584	1904	Length M.	53.50	64.25	80.00
Rosetta	61	46	Varying 9.20 11.70	11.00	2@ 5.5 59@ 5.00	8.00	2915	2944	2944	Width M.	11.83	12.00	12.00

The number of vents of Damietta at present are 51. It was constructed with 71 vents, but ten sluices have been closed in 1887 and ten more were closed during the construction of the new Mohd. Aly Barrages.

As the summer water levels U.S. & D.S. both Barrages will be R.L. 16.50 & 12.70 respectively, each regulator is subjected to a head of 3.80 M. on the assumption that the weirs are in a good working order. However in the case of emergency, both Barrages can withstand the increased head of 7.00 M. (16.50 — 9.50) In the first case the hydraulic gradient is 1 : 24 and in the latter it is 1 : 13.

3. **General Design**

The main features in the design and execution of the main Barrages are :—

a) Two cut offs beneath the floor made up of two lines of mild steel interlocking sheet piling driven at 1.50 M. centres have been provided. The length of these piles is 7.30 M. The space between the pilling is excavated down to a level 1.70 M. from their bottom and is then concreted under water. The lower portion of the space is left untouched to prevent the bottom of the piling moving inwards.

This is an additional safety as regards percolation and at the same time assists in distributing the load on the piers.

b) No large piers and no training walls have been proposed or executed since their advantages do not balance the risks they may involve. All piers have been designed and executed 2.50 M. thick with concrete hearting and granite facing.

c) To ensure stream line flow through the vents, the piers have been designed and executed with a semi — circular cut — water at the U.S. and a tapered tail at the D.S., through their whole height.

d) A deflecting granite weir has been provided, and executed in both Barrages and Behera Regulator; the granite stones were built in the D.S. concrete toe. At Tewfiki Regulator, a lip weir has been constructed as well as the deflecting weir.

e) In the original design it was contemplated to drive one transverse line of sheet piling in the middle of each Barrage running from the U.S. edge of the U.S. block work apron to the D.S. edge of the D.S. subsidiary blockwork apron except across the two cut offs. This has been done under pier No 23 at Rosetta and No 17 at Damietta. Two more lines were driven similarly under pier No 12 and 37 at Rosetta and No 9 & 25 at Damietta to facilitate grouting the floor.

f) In the original design it was contemplated to form four expansion joints in the guide walls of the Damietta Lock, but later it was found necessary to introduce more expansion joints in all the losk walls; guide walls, and abutment walls, not only at Damietta but also Rosetta and Behera, and were formed where there is a change in section.

g) The span of the sluices is made 8.00 M. wide. Five metres span was the General Irrigation practice in Egypt, but this rule was broken for the first time at Nag Hammadi where the span was made 6.00 M.

The width of the roadway between the parapets is 8.00 M. and is made up of a roadway 6.20 M., a footpath near the U.S. parapet 1.50 M. wide and a

granite kerb near the D.S. parapet 0.30 M. wide. The arches are designed to carry a live load of 20 tons lorry and a uniformly distributed load of 450 kgs / M2.

h) Each arch was built in three segments separated by two construction joints. Each segment is free to move by the introduction of grease joints between the segments and the division walls built over the piers. These joints are carried through the parapets and are filled with bituminus sheetings.

i) Another feature of this constructional work is that the whole floor is made up of 7:1 concrete-in-mass and that the superstructure is made up of ballast concrete faced with granite blockers except where dressed granite ashlar stones are specified.

j) Two 4" holes have been made near the U.S. and D.S. noses of the piers for future grouting of the floor. These holes run from the top of the piers to the top of the first layer of the concrete floor which will be pierced through when required.

4. **Piling**

The types of sheet piles used were either Larcens or Mild steel joists and clutches of the universal type. The first type was used in the temporary works and weighs 50 kgs/M run, while the 2nd was used in all the permanent works and weighs not less than 58.79 Kgs. for joists and 23.07 Kgs. for clutches per metre run. The thickness of the web of the joists in the 2nd type was not less than 1 cm.

5. **Floor and Aprons**

The maximum thickness of the impervious floor under the sill is 3.50 ms. This thickness diminishes to 2.16 and 2.06 U.S. and D.S. Damietta and to 1.99 and 1.92 U.S. and D.S. Rosetta. The total length of the impervious floor is 60.00 ms. Upstream and Downstream the impervious floor, block aprons are provided, the length of which is 10.00 ms. U.S. and 15.00 ms. D.S. to the D.S. toe and extends a further distance of 10.00 ms.

6. **Locks**

Both Damietta and Rosetta Locks are 80.00 ms. and Behera 50.00 ms. between centres of gates and all are 12.00 ms. wide.

The site of locks chosen to be in the same direction with the existing old locks.

At Damietta lock, guide walls U.S. and D.S. were proposed to join the existing lock wall with the new structure. The U.S. guide wall was actually executed as designed, but the D.S. guide wall was only executed for 60.00 ms. of its length and the remainder was replaced by a limestone revetment. This was done to avoid the possibility of endangering the weir lock owing to the bad stratum underneath as revealed by the borings carried out during the 2nd season.

Guide piers were made long enough to give boats an easy and safe entrance and exit. The D.S. portion protects boats from the action of the waves produced from the rush of water.

All the hollow Quoins are fine dressed granite, and special care was taken to get them watertight, true to plumb.

The main raft of the locks has been boxed between sheet piles driven to various depths. Additional rows of sheet piling were driven at Damietta lock, owing to the soft silty stratum.

The thickness of the floor is 3.00 ms. of 7:1 concrete-in-mass The upper surface of the lock walls were finished off and finally surfaced with granolithic 10 cms. thick, of 4:1 fine granite concrete laid in alternate sections, abutting to the coping and are on the same level.

Two gauge wells were provided in the guide and return walls of each lock one U.S. and the other D.S.

A mild steel tube lined with concrete 1.00 m. Diam. was laid with vertical shafts underneath the floor of each lock, to take the water mains, electric & telephone cables etc., to the Barrage.

Each lock has been furnished with the following fittings :—

a) Heavy bollards spaced every 12.00 met. inside the lock and about 20.00 met . outside.
b) Heavy fair leads two in front of each capstan
c) Eight lamp posts, four on each wall. The extreme U.S. & D.S. lanterns are fitted with ruby glass round half its perimetre.
d) Heavy galvanised ladder with hand grips recessed into the coping
e) Galvanised hand rails round the gauge wells, and round the top of the boatsteps. Hold fast handrailing is also fitted down the steps,
f) Ringbolts usually in groups of three at different levels.

A safety groove and recesses for raking struts are provided in the walls and the floor.

A scouring culvert 1.00 x 1.80 is formed in each lock wall and is fitted with penstock sluices for regulating the flow.

7. Lock Gates

As the lock gates at Rosetta, Damietta and Behera are all of the same design, the followipg is a general description :—

The lock gates are of the fish -belly type with one single skin plate and horizontal decks built up of plate webs and angles. Two vertical plate diaphragms are provided ta the end on the D.S. side together with a diagonal bracing.

The heel and mitre posts and clapping sills are all of green heart timber.

The heel post is made concentric with the hollow quoin to avoid the trouble of floating debris wedging between the bearing faces as it is the case in eccentric suspension.

A vertical green heart stop 10' long is fixed in the gate recess to avoid damaging the operating gear, as any shock will be directly communicated to the lock wall. Additional fenders are also supplied between the decks where the spacing is more than 4'6".

Each gate is fitted with two hand-operated filling sluices 3'x 2'.

The top anchorage consists of a steel casting bolted to the gate with a bearing, over which a cast steel collar is fitted. The coller is held by three pairs of links attached to adjustable eye bolts fitting into bosses on the anchor block.

Each gate is operated by a rack arm hinged to the U.S. side and is well above the max. water level.

In addition to the four double-purpose capstans of the gate operating gears, two wrapping capstans are fitted in the lock walls near the D.S. entrance. The Tewfiki lock gates are flat on both sides U.S. & D.S. with the skin splate on the U.S. and diagonal bracing on the D.S. The clapping sills and mitre posts are made of green heart timber while the heel post is of steel. The old hollow quoins and standing, sills which are of C.I. were retained and had to be cut and dressed where worn out.

Each gate is fitted with two double filling sluices of normal design with a clear opening 3'9" x 2'6" divided in two parts between the bottom and the second and between the second and the third decks.

The gates are operated by hinged arm attached to the gate near its top at about 3/4 of its length from the heel post centre and a chain attached to the gate at the same distance from the heel post and about 8' above the sill.

8. Swing Bridges

While the foundations for the roller path and land abutment for the Damietta, Rosetta & Behera bridges form part of the lock land wall, it is in the case of Tewfiki bridge built on a reinforced concrete raft and piles.

The bridges are all designed for a max, live load of one 20 Ton ploughing engine + a uniformly distributed load of 488 kgs./M2 on the remaining area. The max, permissible stress is 7 Tons/П" (1100 kgs. cm2), and while half the total load is carried by the pivot, the other half is carried by the rollers.

The foot paths and a narrow strip of roadway on each side are carried on cantilever brackets built out from the main girders. In the Tewfiki bridge the main girders are outside the foot paths and form the main part of the paperet; part being above and part below the roadway level.

The roadway and footpaths are surfaced with 4: 1 fine granite concrete laid in sections. The joints are arranged as far as possible in line with the centres of the cross girders.

The moving portion of the bridge is balanced by C.I. kentledge blocks loaded in compartments under the roadway at the tail end and by heavier C.I. blocks bolted outside the main girders and tail end cross girder. At Tewfiki the compartments are under the roadway and footpaths and no outside blocks used.

The wedging gear is provided at all four corners of each bridge; each wedge is operated independently by a hand wheel on the underside of the main girder. At Tewfiki the wedges are operated by hand wheels on the top.

Spring buffers are only provided at Tewfiki.

9. Sluice Gates & Operating Machines

All vents are fitted with two gates of equal height. The D.S. gate is intended to be used as the bottom gate and the U.S. gate at the top. This arrangement can however be changed but the U.S. gate cannot be used in the D. S. groove and vice versâ.

For ease of staunching, the skin plates of the two gates are adjacent to one another. The skin plate of the top gate is on its D. S. side while that of the bottom gate is on the U.S. side. Arrangement is made for both horizontal and vertical staunching.

Each gate is suspended by two chains with links 10 cms, pitch the chains are spragged on heavy built up girders supported in recesses in the parapets.

Finer regulation can however be made to 2.5 cms by changing the position of the spragging block which is designed with four holding positions.

Each gate is fitted with rollers which run on machined facings on the single groove casting. One gate works inside the cast iron groove on the D. S. flange while the other gate works inside the granite faced groove on the outside face of the U.S. flange. The groove castings as well as the rollers are made of "Mechanite Cast Iron" which has a higher tensile strength compared with grade "A" cast iron and has better resistance to corrosion.

At Rosetta and Damietta the gates are operated by two over-head power-driven machines spanning the roadway and are run on rails fixed on the extreme U.S. parapet and on the D.S. parapet wall. Each machine is provided with duplicate power units and duplicate electric lighting sets. The main power unit is 51 B.H.P. four cylinde petrol engine driving through a Daimler fluid coupling.

At Behera the gates are operated from a single low level power-driven machine which runs on the two U.S. parapet walls. The machine is also fitted with duplicate power units and electric lighting sets.

Each of the Tewfiki and Nagayel Regulators is fitted with one low level hand-worked machine which runs on the U.S. parapet walls.

The main particulars of the grooves and sluice gates are appended.

10. Light, Water, Telephone and Drainage Arrangements

The Diameter of the different pipes are as follows :—

Water Mains	5"
Electric Power Conduits	4"
Telephone	3"
Electric Light	2"

All are formed of mild steel screwed and socketed steam pipes galvanised both inside and outside, and are run from the East approach of the Tewfiki to the West approach of the Behera through sub-ways under the new locks. At Tewfiki lock chases were cut in the sides and sill to receive the water main and cables.

Two lamp posts are erected at every bastion one on the U. S. parapet and the other on the D.S. parapet.

The lanterns at both entrances of the locks have been fitted with ruby glass one half of the perimeter.

For drainage purposes the road – way over the Barrages and regulators is made sloping 10 cms. towards the U.S. parapet, and rubbish shooth were arranged every other vent.

11. Materials

a) — Granite

All granite required for the works was obtained from the well known Shellal Quarries, which were chosen jointly by H. E. the Under Secretary of State and the Consulting Engineer. It is of the coarse grained variety of a uniform pink colour, with specific gravity 3.2 and bearing stress 2600 K/cm2. absorbsion in 24 hours .03 %. Granite was mainly used in : — (1) Blocker facing of the lock walls, abutments and piers. (2) Ashlar in quoins, sills, parapets, copings and other works. (3) Pitchers in the floor of the vents.

Two granite crushers were installed at both Damietta & Rosetta yards for crushing the aggregate required for the concrete of the arches. The aggregate was specified to pass a ring 1" diam.

b) — Ballast & Sand

Ballast and sand for concrete and Mortar were obtained from Birkash, where they were quarried separately and free from foreign materials. The following table

shows the mean percentage of grading of the ballast as compared with the specified percentage.

Retained by a ring	Passed by a ring	Percentage	
		Contract	Actual
1 ½"	2"	22	20
1"	1½"	30	30
½"	1"	30	31
—	½"	18	19

Several tests were made to get the excess in bulk of a given quantity of ballast when mixed dry with 50 % of its volume of sand. The average excess was noted to be 20 % and the amount of cement was fixed accordingly.

The following table gives the proportion of aggregate for the different classes of concrete used ; –

Materials	Mixture of one Batch			
	7 : 1	6 : 1	5 : 1	4 : 1
Ballast	.42 M3	.45 M3	.45 M3	.42 M3
Sand	.21 M3	.22 M3	.22 M3	.21 M3
Cement	2 bags	2½ bags	3 bags	3½ bags
Ratio	1:3:6	1:2.5:5	1:2:4	1:1.5:3

No special mechanical devices were used for sieving since the grading of the ballast when quarried complied with that required by the specification.

c) — Cement

All the cement used in the work is manufactured in Egypt by Tourah and Helwan works of the Comptoir des Ciment and passed the B.S.S.

Cement was supplied in 250 tons consignments in fine paper bags.

The consignments were used in the order of their delivery to avoid deterioration by over storage.

Samples of each consignment were tested at M. A. Barrages Laboratory as well as Tourah by Mr. Harry Stanger's representative. Check tests and analysis were carried out at Stanger's Laboratory at London in accordance with the specifications.

The results for average tensile strength on consignment No. 54 are tabulated thus :—

Paste	Age of Paste	M.A. Lab. lbs.	Stanger's Lab.		Percentage of Water					
			Tourah lbs. in2	London lbs. in2	M.A. Lab.		Tourah Lab.		London Lab	
					neat	sand	neat	sand	neat	sand
	Days	in. 2								
Neat	7	1127	1310	1273	21.1	7.8	22.0	8.0	20.50	7.9
3 sand : 1 Cement	7	523	505	455						
3 sand : 1 Cement	3	555	542	547						

Out of the total 106,625,000 tons of cement used on the works, about 50 tons were found to contain hard lumps which on analysis gave a residue of 15°/o on sieve No. 72 where as the 1931 British Standard Specifications does not allow more than 1 °/o. This cement was crushed, seived, and although passed the tests, was used in minor works such as pitching in mortar and other temporary works.

d) **Limestone**

The common white limestone used in pitching the slopes and under the block work aprons was obtained from Tourah Quarries. Ashlar stones for repairing and reconditioning the Tewfiki head regulator and the Ancient gate way were supplied from Tabaket Ahgar El Shawish Quarries. Samples of ashlar stones were tested in the M.A.B. Laboratory and in the Chemical Department Cairo and were found suitable.

e) **Bricks**

The bricks used in the extension of the Tewfiki arches, piers and guide pier were wire cut bricks as the Contractors failed to supply good quality ordinary bricks. The crushing strength of the former is 100 kgs./cm^2 while it is only 50 kgs. / cm^2 for the latter.

f) **Asphalt Paving Bricks**

Asphalt paving on the roadway of the barrages consists of bricks 20x10x5 cms. manufactured by the Egyptian Road Constructian Co., bedded on 2 : 1 cement mortar 2 cms. thick and grouted with neat cement.

The bricks were tested by applying half a ton load on a cube 5x5x5 cms. for 30 minutes. Through out the test, the Asphalt brick shall be maintained in a hot water bath at 71°C temperature. The specified depth of the indentation resulting from the above load shall not exceed .75 m/m and the brick should show no signs of cracking or distortion.

g) **Painting**

As specified all gates were painted with three coats of a tar pitch composition applied hot with the exception of three pairs at each Barrage which were tested for each of the following compositions and the results will be known later:—

A — 2 coats of red lead and 2 coats standard tar mixture.

B — 2 coats of red lead and 2 coats of Esna tar mixture.

C — 4 coats of the standard tar mixture.

D — 4 coats of Esna tar mixture.

The composition of the two tar mixture is as follows:—

a) **Standard Paint**

Coal tar B.S.S. No. 76 consistency 50-60 seconds. .	80 °/o by wt.
Pitch, medium coal tar pitch.	9 °/o »
Naphta, heavy coal tar naphta (Unrectified) B. S. S. No 479 C 1933 Quality B	8 °/o »
Lime, best Bux-ton quality quick lime in lumps to pass a 3/4 inch mesh sieve	3 °/o »
Total . .	100 °/o

b) **Esna Paint**

Coal tar; neutralised	93 °/o by wt.
Boiled linseed oil	2 °/o »
Turpentine	5 °/o »
Total . .	100 °/o

The boiled oil is to be added when heated to 90°C, stirred for 10 minutes and the turpentine is then added and the whole stirred for a further five minutes.

The results so far obtained after the gates being in use for two years confirm that those painted with two coats of red lead and two coats of tar composition are in a better condition than those painted with four coats of tar composition only.

ADJUDICATION

1. List of Works and Tenders

In December 1935, tenders were invited fort he construction of the following:—

1) Two new Barrages with navigation locks across Damietta and Rosetta branches and a new head regulator with a navigation lock on the new approach of Behera Canal.
2) Reconditioning of the Tewfiki head regulator and lock.
3) Reclamation and construction of Damietta branch West bank.
4) A new hydraulic research laboratory.
5) Reconditioning of the Western Ancient Gateway on the line of the new roadway.
6) A new intake for Nagayel canal with a of Tewfiki Head Regulator.
7) Roadway bridges across Darawa Canal and the Experimental Channel of Hydraulic research laboratory.
8) New bridge with opening span at the lock of Tewfiki Head Regulator.
9) Roadways,
10) Sluice gates, machinery, lock gates, etc.

Tenders were opened on noon 7th April 1936 and are tabulated below:—

Mame of Contractor	Amount of Tender L.E. m/m
1. Tilbury Contracting and Dredging Co. (Co foreign) Ltd., Bæhler, Savoy Building, Cairo	2,376,037.760
2. Macdonald Gibbs and Co. (Engineers) Ltd., 28, Finsbury Square, London, E.O. 2	2,486,133.406
3. Société Générale d'Entreprises, 56, Rue Faubourg, Paris. .	2,517,235.874
4. Schneider & Cis, 42, d'Anjou, Paris	2,544,055.400.
5. Gibson & Pauling (Foreign) Ltd., Shell House, Cairo . .	2,557,282.390
6. John Nolin & Co. Ltd., 91, Ebury Bridge Road London, S.W.1	2,609,187.004
7. Edmund Nattal, Sons & Co., 22, Grosvenor Gardens, London S.W.1	2,627,453.770
8. Société Anonyme Hersent, 60, Rue de Londres, Paris . .	2,648,771.078
9. Sir Lindsay Parinson & Co. Ltd., Shaftsbury Avenue, London	2,746,365.723
10. John Cochrane & Son Ltd., 39, Victoria Street, London, S.W.1	2,775,581.047
11. Charles Brand & Sons Ltd, 25, Charles Street, London. S.W.1	2,795,323.530
12. Balfour, Betty, Co. Ltd, 66, Queen Street, London, E.C.4 .	2,949,113.963

The time for completion quoted in all the tenders, with the exception of tender No. 8, varied between 15th October 1939 and 31st December 1939.

The Consulting Engineers completed their examination & reported fully, in due course, with their recommendations, but the Ministry, desirous for further considerations, asked the tenderers to extend the validity of their offers till october 1936, and to which all, except N° 6, 10 & 11, agreed without any reservation

On 30th October 1936, H.E. the Minister Osman Moharram pasha gave the contract to Messrs Macdonald Gibbs & Co. and on the same date, the Ministry ordered the appointed Contractors to start work.

2. Subsidiary Adjudications

The Contractors, in accordance with the terms of the general contract, asked some selected firms to tender for all steel work.

The tenders which were recommended by the C.E. and accepted by the Ministry are :—

a) Messrs Ransomes & Rapier's to do the Sluice Gates and operating Machinery for a sum of L.E. 209,800.000m/m.

b) Messrs Head Wrightson & Co's to do the Lock gates & swing bridges for a sum of L.E. 95,767.000m/m.

3. Order of procedure & Execution

In tendering, all Contractors were notified that the construction of the two Barrages, Damietta & Rosetta, shall be put in hand in the same time, and the execution there of shall run concurrently as follows :—

1. The locks, guide walls, guide piers in both Barrages shall be constructed during the first season together with a short length of each Barrage.
2. In the second season both Barrages shall be proceeded with providing sufficient waterway, for the passage of river craft, etc, until the new locks shall be opened for navigation, and for the requisite discharge of the river.
3. In the third season both structures of the Barrages should be completed.
4. The Behera regulator shall be constructed in the dry previous to the cutting of the existing ground of the new diversion.
5. The reconditioning of the Tewfiki floor should be done during the closure periods.

The contractors, however, have submitted the following programme for execution :—

1. Damietta

First season: construct lock and 1 1/2 vents.

Second season: construct Barrage up to vent No. 17.

Third season: complete the construction of all the Barrage (34 vents).

2. Rosetta

First season: construct lock and one vent.

Second season: construct Barrage up to vent No. 22.

Third season: complete the construction of all the Barrage (46 vents).

3. Behera

The construction of the Behera head regulator and the new diversion will start from October 1936 and to be completed in June 1939.

4. Tewfiki Head Regulator

The reconditioning of the under water work of the Tewfiki regulator will be undertaken in the closure period of 1937-38, while the work above water level will be proceeded with as found convenient.

5. Nagayel Regulator

The new mouth of the canal will be constructed in the first season, a temporary diversion of the canal will be started about 1st October 1937, and completed in the beginning of closure period 1937-38. The regulator will be completed in the early part of 1938 to obviate interference with the construction of Rosetta abutment in the third season.

6. Hydraulic Research Laboratory

The entrance for the experimental channel will be constructed during the first season with the pitching on the left bank U.S. the new Barrage. The outlet will be constructed during the third season. The rest of the work in connection with the laboratory will be eonstructed as found most convenient.

7. Remaining Subsidiary Works

The construction of road bridges, the Ancient Gateway and roads will be carried out as found most convenient, as they are hardly affected by river conditions.

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As will be seen from the seasonal works described later, the Contractors could not stick to the proposed programme of execution partly due to the difficulties met with in the Damietta first season, and partly to the trials and experiments carried out at Behera, but they finally suceeded in substantially completing the works on the alloted date

DAMIETTA WORKS

A — LOCK

SECOND SEASON

A- Lock Floor

1) Cleaning & Inspection.

After cleaning the lock floor from the silt deposited during the flood, the 380 M3 concrete U.S. the subway which were not executed in the first season, were first concreted.

Inspection of the floor had revealed some hair cracks. Some of them were at the construction joints, and although they were not detrimental to the structure, the following measures were taken for their remedy. Water coming through these cracks was quite clean and no sand was carried away from underneath the foundation.

2) Cracks in Floor & their Treatment

a) **Crack AA:** This was a transverse crack across the floor of the lock and is situated about midway along the length of the concrete floor, a little distance away from the expansion joint of the wall.

The remedial measures taken were cutting the floor to the extent, and placing a standard expansion plate in the bottom of the trough overwhich a steel trough of rectangular section was placed. Before levelling the bottom of the trough with 2:1 cement mortar, all the water coming through was lead in a small trough cut in the surface of the concrete floor. Holes were drilled at both sides of the trough 1.50 ms. apart in which bondig rods of 1.25 ms. long and 1.25" diam., were grouted with neat cement. The whole section was then filled in with, 4:1 concrete in two longitudinal sections and was grouted under a pressure of 30 lbs./□". The adjacent expansion joint in the wall was removed opposite the site of the crack.

b) **Crack BB:** This crack is situated immediately upstream the axis of the Barrage and where the 3rd lift of concrete was not done in the last season. A semi circular steel gutter was laid over it and the water coming through the crack was led outside the lock floor and the 3rd layer of concrete was deposited. Later on this gutter was connected and grouted with the drainage system of the D.S. raft of the Barrage. Two holes, one on each side of the crack were drilled and grouted to fill any possible cavities under the floor.

c) **Crack CC:** This is situated in ths ramp D.S. the subway. Reinforcing bars were placed on the crack before concreting the top lift and on the ramp which had been modified.

B) Guide Walls

1) Excavation and Piling

a) **U.S. Guide Wall:** The process of the execution of the foundation of these walls necessitated extreme care on account of the difficulty in excavating the low level soft material and replacing it with sand, and also the possibility of undermining the existing structure and the floor of the new lock. Although the measures taken were successful in safe — guarding the said structures, yet at the last moment, a tiny crack developed in the walls of the old lock due to pumping operations. It was intended in accordance with the Contract to drive sheet piles around the U.S. end of this wall where it joins the land wall of the old lock for protecting the latter during excavation, but as it was found inadvisable to cut through the old concrete foundation for this piling, the temporary augree piles 13.00 ms. long driven at the D.S. end of hommra concrete floor of the old lock were extended through the old hommra concrete toe of the revetment.

The design of the foundation of the upstream guide wall was modified as follows:— The 6.00 ms piles were replaced by 10.00 ms. and the river side line was driven outside the old timber piles, thus providing a bigger toe.

It was also decided to found the most southerly section on the old hommra concrete cut down to R.L. 10.00 and to place an expansion joint at its north end.

Excavation in U.S. guide wall proceeded by removing the old hommra concrete toe and revetment. The area was divided into compartments by adding steel piles crosswise. The steel sheet piles were strutted firmly against each other, but in spite of the heavy strutting the back piles bulged even after relieving the piles from the heavy load of the bank by cutting, it to a flatter slope.

b) **D.S. Guide Wall:** As borings were carried out between the existing weir lock and the new lock showed the existance of reliable strata at R.L. 1.00 — R.L. 3.00, it was considered unsafe to excavade the whole of the soft strata to this level. The design was therefore modified and the wall was stopped before this deep pocket and was substituted by pitching in mortar.

2) **U.S. & D.S. Toes of Lock:** The U.S. & D.S. Toes were excavated in the same way as the out off, except the U.S. end of the U.S. toe which was excavated by hand and was executed higher than the designed levels.

Concreting Floor & Grouting the Guide Walls

The floor of the U.S. guide wall was concreted in steps and part of the timber strutting was left in. Reinforcing bars were placed in the whole length in order to extend the wall to the designed width outside the bulged piles.

Three small hair cracks developed in the 1st. lift, over one of them reinforcement bars were placed and the other two occured near the designed location of two expansion joints to which they were transferred. All these cracks did not appear in the top lifts of concrete.

The floor of the D.S. guide wall was deposited, in two lifts.

Grouting the floor of the Guide Walls was carried out under pressure as previously described in the locks except the U.S. box of the U.S. Guide Wall which was grouted under gravity owing to the egress of liquid cement from between the concrete apron and the Larssen piles at the U.S. end.

4) Concrete Blocks

This is dealt with under Regulator.

5) Masonry

The masonry of the lock walls proceeded as described in the previous season and after constructing the culverts, the progress advanced rapidly. By the end of July the lock and guide walls were brought up to R.L. 17.10. By 5/11/1938, all the masonry of the lock was completed with the exception of the granolithic surfacing and part of the coping.

The dressing of the bearing faces of the temporary dam recesses was carried out before the arrival of the flood.

6) Pitching

A mattress of gravel 0.30 M. thick was introduced below the designed thickness of limestone. To pass any seepage water, weep holes have been arranged by fitting .10 M. pottery pipes between R.L. 9.00 & R.L. 15.70.

7) Steel Work

No steel work was done in the lock this season.

8) Old Lock Wall

Inspite of all precautions taken to avoid the under—mining of the existing structure, a small crack developed in the land and river walls of the old Damietta lock. Holes were drilled in both walls, and grouting was not carried out this season owing to the head on the Barrage and was postponed until such a time when the Barrage was fully opened.

THIRD SEASON

1) Grouting Cracks in Old Barrage Lock Wall

The cracks which developed in the old lock walls showed a slight movement. They were grouted under pressure in January 1939, when the Barrage was fully open. The number of cement bags used was forty. No movement was noticed after the grout has set.

2) Mosonry

The work was resumed slowly, early in September 1939, to finish what was outstanding from the first two seasons, and laying the granolithic paving was completed.

Two sudds were constructed at the U.S. & D.S. temporary dam recesses to allow for the erection of the lock gates.

The lock was dried off and a start was made in dressing the hollow quoins and the pressure faces of the sill stones for the lock gates. All the hollow quoins were built projecting three millimetres to allow for the finishing process. To dress these quoins to an absolute tight fit with the green heart of the heel posts, the theoretical vertical axes points of the gates were fixed on the pivot blocks with great accuracy. The vertical axes of the gate heel posts were indicated by heavy cylindrical solid plumb bobs hanging from piano wires and submerged completety in castor oil to secure them against wind oscillations. The adjustment of the vertical wires was done by means of small hand winches on a steel plate which was secured over the hollow quoins at quay level. After fixing the plumb wires in the required positions, a complete survey of the hollow quoins around the meeting faces was made relative to the plumb wires. Skilled dressers were employed in this work. On completion of the dressing, 'these quoins were tested with machine - cut steel straight edges and templates to satisfy a tolerance not more than. .02 m/m.

It was specified to rub the finished surface with carborundum and sand, but it was realized from previous practice that the above mentioned treatment produces a wavy surface when applied to coarse grained grainte, and so no sand was used and bare carborundum blocks were only applied to obtain the finished surface.

It took about 63 days to finish in situ the meeting faces of the hollow quoins and the pressure faces of the sill stones.

3) Subway Lining

The interior of the subway and shafts was lined with 25 cms. of 4:1 fine granite concrete. The lining for the horizontal tube was carried out in the following manner :—

The lower part was first cast in sections indicated on drawing No 38 breaking the joints with the steel tube. The key segment left at the top was then concreted in sections varying in lengths from 1.00 to 1.50 ms. thus avoiding the existance of vertical joints in one plane through the concrete ring.

A grouting hole was formed at the top of the key segment for the full length of the horizontal portion by means of 2" pipe removed before the concrete has set completely. Connections to this hole were made at five points by means of short lengths of 2" pipe provided with screw caps.

The lining for the vertical shafts was laid in sections each about one metre in height.

Work started in concrete lining on 8th. May, 1939, and was suspended on 15th. July after finishing the horizontal tube and the two end boxes with 1.30 M. up the river shaft and 2.20M.up the land shaft to allow for grouting which was done on 23rd. July, 1939.

The 2" hole formed in the top segment of the lining in the horizontal tube was grouted under a head of 8.00 ms., through pipes extending up both shafts. Sixteen bags of cement were used.

The sealing of the leaks in the concrete could be observed during the process. After grouting, the work was resumed in both land and river shafts till it ended on 16th. August 1939.

4) Cleaning Down

When all the under flood water works were completed, the plant was removed and the floor cleaned down from rubbish and mortar droppings. The face work of the masonry was thoroughly cleaned from extraneous cement mortar. The lock culverts were inspected, and rendering the sides was made where necessary.

5) Steel Work

During this season the lock gates and swing bridges were supplied and erected completely.

B—BARRAGE

SECOND SEASON

1) Sudd, Temporary Piling & Dewatering

The formation of the sudd started on 3rd. November 1937, from spoil excavated by dredgers from the foundation of the sections to be built this season, and from the remains of the 1st seasons sudd which had not been washed away by

the flood. On December, the dredgers were removed, the sudd was closed, and dewatering followed shortly. The maximum number of pumps used to cope with the infiltration water were :—

1	@	16"
2	@	12"
2	@	8"
2	@	4"

Temporary piles were driven according to the previous agreement. (see general notes on sudds).

2) Permanent Sheet Piling

Driving of sheet piles for the U.S. & D.S. diaphragms, U.S & D.S. cut offs and the D.S. toe started on 2nd February 1938 and ended on 31st May 1938.

3) Removal of Scar End 1st Season

The temporary piles protecting the scar end of the 1st season were extracted, but owing to the ground resistance 15 piles U.S. the D.S. cut off were burnt off at R.L. 8.50. The dumped rubble was removed.

4) Excavation

a) Floor

Excavation began on 28th November1937 by dredgers, and spoil was used in forming the sudd. When the sudd was closed and the area dewatered, hand excavation started and proceeded till 25th March 1938, when it was completed.

b) Cut Offs and Toes

Excavation began on 2.3.38 and 1.3.38 and ended on end of May and 15th July, for cut offs and toe respectively, using sand pumps.

5) Concreting

a) Cut Offs and Toes

Concreting Cut Offs was carried out in sections of 8.00 ms. alternatively and was at least one pool ahead af the floor. The concrete was deposited by means of special under-water skips handled by a steam crane. Concreting any section was continued without cession until it has been completed for the full length and height. A key was formed between each section by means of a tapered core .50 x 1.30 ms. attached to the back of the steel bulkhead shutter.

Experience has proved that the bulkhead shutter could bear on the clutches and thus the angles specified for such purpose were after sometimes no longer used. The bulkhead shutter was eased in position after depositing the concrete by twelve hours and was completely withdrawn after 24 hours.

The method adopted in concreting the Cut Offs was employed in concreting the toe for the first two metres in depth, which were allowed to set hard, and then the upper portion of the trench was dewatered, and the remainder of the concrete deposited in the dry. The chase .85 m. wide and .55 m. deep, prescribed in the contract for the reception of the granite deflecting weir was avoided for the difficulty experienced in setting the stones of the granite weir. The stones were set in place on the stepped concrete, and the front portion had to be concreted later. This simplified to a great extent the bedding of the stones.

Remedial measures for sealing the spring which appeared in the U.S.. Cut Off at the end of first season were taken by leaving a section 1.50 ms long confining the spring, and the remainder of the pool was concreted in the ordinary way. When the concrete had set hard, pumping was stopped and water was led to flow outside the area of the barrage. Two holes were drilled in the lock floor, one on each side of the cut off, and grout was forced in later to fill any possible cavities.

While excavating the D.S. Cut Off, numerous small springs appeared on both sides of the sheet piling and specially at the D.S. line which resulted in lowering the ground level owing to the movement of sand. A layer of gravel was laid as a filter and timber sheet piles were driven round the D.S. springs to enclose the springs as they were found to be moving.

b) **Floor**

Bonding iron bars 1 1/4" diam. 1.50 ms. apart, were placed for bonding the new with the old concrete. Concreting the floor was done in two lifts, with overlapping joints between the layers. It was arranged to make the construction joints of the central pools under the piers, and the pools were divided to suit the daily output of the mixtures.

Rough shutterings with vertical and horizontal keys were provided to form the vertical construction joint.

Previous to depositing any concrete, the surface and ends were thoroughly picked, washed and cleaned. Great care was taken to water the concrete after covering it with sacking for a period not less than 10 days after it had been deposited.

Surface cracks developed at some of the construction joints in the 1st lift. Reinforcing bars were laid over them on concreting the 2nd lift.

When test pits cut in the cracks showed that they did not extend downwards more than two to five centimetres from the surface, and being superfluous, reinforcement was no longer used.

7) **Grouting**

Grouting the floor was done on the same lines as proviously described in the lock.

8) **Concrete Blocks Making and Laying**

Block making was started on 27.4.38 and continued until 29.9.38. The total number manufactured amounted to 4525 and 30 complete and half blocks respectively. Owing to the late start, the Contractors were allowed to lift and set them after 5 and 21 days instead of 7 and 30 days after their manufacture as specified. The blocks were set dry on a bed of Tourah limestone .50 m. thick, hand packed and surfaced off to a true plane. Certain parts of the block work apron of the Barrage as well as U.S. the lock were replaced by 7:1 concrete in mass; the former to act as a foundation for the temporary wall used in completing the temporary sudd of the third season built in continuation of pier No. 19 while the latter is made to stop any grout leaking through the clutches.

Block laying was started on 22.3.38 and ended on 22.7.38 and the number of blocks laid this season amounted to 4794 blocks and 60 half blocks.

9) **Masonry and Concrete Filling**

a) **Piers and Vents**

The method adopted in building the granite facing and the concrete filling was the same as previously described in the lock.

The last two piers were built up only to R.L. 15.70 and R.L. 12.50 in order not to impose too heavy loads at the scar end. Recesses were formed in the piers to receive the cast iron grooves, and holes were formed in these recesses by means of steel gas-tube liners 3" internal diam.

These liners were greased and revolved at intervals during the setting of the concrete in order to be able to withdraw them easily.

b) **Sills and Pitchers**

All header pitchers were first built after, either cutting a chase in the floor to receive them or by preparing a base of granite masonry or concrete to the correct levels. The spaces between the headers were then filled with 5:1 concrete up to the levels required to receive all other stones which were set on bed of mortar, and grouted with 2:1 cement mortar, the joints being not more than 1.5 cms. The sill stones were set dead level before the adjacent pitchers.

Serrated swords were worked in the joints to ensure the complete filling of the whole depth

The sills were fine axed over a minimum width of 12 cms. and finished in situ to a perfectly true and level plane to receive the bottom of the sluice gates.

c) **Granite Deflecting Weir**

The stones were of random lengths, not less than 1.25 ms., set on a bed of 2:1 cement mortar and the joints not exceeding 1.5 cms. After depositing the remaining portion of concrete, the stones were grounted from V grooves with 2:1 cement mortar after pointing the sides with 1:1 cement mortar.

10) **Observation Pipes in the Piers.**

With a view of ascertaining the hydraulic gradient when the Barrage is in operation, observation pipes were fixed in pier No 23. The pipes are 6" diam. Steam tubes, with screwed and socketed joints, galvanised inside and outside and had been led from the underside of the imprevious floor up to the top of the pier. The bottom of the pipes were housed inside a perforated drum full of graded ballast, covered with canvas before depositing the concrete. Great care was taken to safeguard the drum against grouting or mortar, and during construction the top of the pipes were carefully closed to preclude the admission of any material. The tops of the pipes were housed inside a cast iron box.

11) **Holes in the Piers for Future Grout.**

Every pier was fitted with two 4" holes at the U.S. & D.S. noses except those in which observation pipes are fixed, for future grouting under the foundation. The holes were cored by tubes 4" diam. which were revolved and withdrawn before the concrete had set hard. The holes were led from the top lift of the concrete floor to the top of the piers. It was essential to set the tubes truly vertical through every layer of concrete hearting.

Construction of Arches.

The centering of the arches was formed of mild steel plates resting on heavy mild steel frames which in turn rest on longitudinal joists which were suspended from cross beam resting over the top of the piers.

Four sets of centerings were supplied. After the centering had been fixed for the main arch, the granite skew backs and filling stones were built, after which the concrete - in - mass skew backs and the lower portion of the Division wall were formed. The granite vousoirs of the main were then set and the joints were stopped and grouted. After the masonry had set, the 4 : 1 fine granite,

concrete - in - mass forming the road - way arches was deposited in three segments with true radial joints running right accross the arch formed by straight shutters at right angles to the axis of the Barrage.

The two joints in concrete were in line with the joints in the granite vousoirs. The key segment was deposited after the elapse of three days of depositing the lower segments, which were deposited at one time so as to have an even distribution of the load over the centrings. The thickness of concrete in the arches was not less than. 90 ms. The final pointing of the key stones was usually carried out after the completion of the concrete arch ring. This is to avoid any possible developing of fine hair cracks in the pointing. The centring was not removed before the elapse of 14 days from the completion of concreting.

The number of arches completed during the season was 15.

The centring and granite vousoirs of the flying arches were constructed in the same way.

13) **Construction of Division Walls.**

A division wall of 7:1 concrete was formed on the top of the 4:1 concrete skew back on each pier. This was formed to true surfaces and dimensions by timber shutterings. The sides of the wall were washed with a heavy coat of soft soap and lime before depositing the concrete filling. At the half pier such joint was avoided.

14) **Construction of Spandrel Walls**

Construction of the spandrel walls was started after the elapse of one month of concreting the arches. This is followed by depositing the 8:1 concrete filling. A transverse construction joint at right angles to the axis of the barrage was formed in in the spandrel filling concrete over the centre of each vent. Longitudinal chases were formed where necessary for the mains, kerbs, etc. & recesses were left in the mass concrete for the reception of surface boxes, drains, and other fittings.

15) **Construction of Superstructure.**

A temporary bridge and a decauville track for handling the concrete of the spandrel filling was laid across the lock. Also a crane was arranged to run on rails over the piers during the flood period.

After the completion of the piers, the crane was allowed to pass after the elapse of two weeks.

A travelling crane was placed on the concrete filling after the elapse of one week its depositing, for handling the stones of the superstructure.

As the transverse arches across the sluice wells, the bastions and pilasters are incorporated and from part of the division wall, their construction was done concurrently

A hidden joint was kept open at the back of each bastion and pilaster above R.L. 20.70. The joint between the granite fillers in the spandrel and the parapet walls was filled in with two layers of rubberiod.

16) **Steel Work**

The cast iron grooves were erected from the east pier as far as pier No 19. The erection of the grooves followed the construction of the piers and was dependant on the progress of the latter.

The castings were held in place by long galvanised 1 ⅛" bolts in the piers and by shorter masonry bolts at the abutments.

No sluice gates were delivered this season.

17) **Scar End**

a) **Floor**

As the transverse diaphragm under pier No 17 was near to the scar end, it was unnecessary to drive another line of piling. Only a temporary line of sheet piling 7.30 ms. long was driven at a distance of 19.75 ms. from the axis of pier No. 17 and the block apron was extended to this line. The space between the temporary line and the scar end of the impervious floor was filled with limestone rubble. Bonding irons 5.00 ms. long were embedded in the end of the floor for bonding with the new concrete of third season.

Another transverse diaphagm was driven under pier No 19 as a base for the sudd piling of the comming season. The same diaprhagm was extended up and down stream the ends of the block apron and over which the blocks were replaced by 7:1 concrete in mass, 15.00 ms. wide on which a temporary masonry wall was founded with a view of sealing the foundation of the barrage at the position of the 3rd. season's sudd. Both U.S. and D.S. block aprons were blinded with sand for a length of 20.00 ms.

b) **Superstructure Scar End**

Pier No 19 have rails built in the top of the concrete-in-mass. The lower filling stone between the skew of the granite arch of the end pier was omitted and replaced by concrete to leave room for the end rails. The piers No 19, 20, 21 and 22 were tied together by means of two 3/4" diam. mild steel bars cast iron washers and coupling nuts.

Mild steel liners of 3 ½" diam. gas tubes were used in forming the holes through the piers. Mortar pads have been formed under each washer to distribute the load evenly over the rough surface of the blockers. The tie bars have been located to overlap the reinforcement of the pier No 19 as much as possible.

18) **Cleaning Down**

In the latter half of July the floor and the piers were cleaned and inspected, all concrete and mortar droppings, were removed.

19) **Breaching of the Sudd**

The extraction of the temporary piles started on 19th. June, and was completed on 25th. July. Cutting in the inner face of U.S. portion was started on 20th June, proceeded slowly till 1 p.m. on 31st. July, when pumping was stopped, and at 10 p.m. on 1st. August the sudd was breached.

20) **Flood 1938**

Dredging the remains of the sudd started on 2nd. August and proceeded till 10th September, and owing to the high levels of the flood dredging could not be continued. The construction of the arches, the superstructure, the lock and guide walls, pitching in mortar for the Nile Bank D.S. the new lock was continued during the flood. A portion of the D.S. pitching in mortar was built temporarily with dry rubble limestone from level 15.70, with a view of dismantling it in making an approach to the temporary gantry next season.

A tug was used to lead the boats from the old lock of the existing barrage to the west side of the river to facilitate navigation.

Soundings were taken periodically at the side and no scour was noted.

THIRD SEASON

A) **Regulator**

1) **Sudd and Sudd Piling**

Pile driving for the sudd started on 10/11/38 and proceeded until 12/1/39, when it was completed. It was carried out by means of a floating plant.

The piles were of the Augree and Larseen type and the number of piles was 678 at the U.S. side and 347 at the D.S. side. These piles were driven down with their bottoms between R. L. 6.00 & R. L. 2.00 to confirm with the results of borings made. On closing the gap upstream, as driving was continued from both sides, the bed of the river was scoured from R.L. 9.00 down to R.L. 4.00 and a stone bar had to be constructed before it could be closed.

The formation of the sudd started on 22/11/38, from the spoil stacked on the west bank during the second season, and by dredgers from the foundation area of this season, and from spoil brought from Shair Island. The sudd was closed on 7/1/39 and strengthening proceeded.

2) **Dewatering**

This was started slowly on the 8th January immediately after the sudd was closed. The number of pumps that dealt with the infiltration water were as follows:—

1	@	16"
1	@	14"
3	@	10"
3	@	8"

3) **Excavation**

a) **Floor**

Excavation started by hand on 15/1/39 and was completed on 10/4/39

b) **Cut Offs and Toe**

Excavation started on 20/2/39 and ended on 16/4/39 and was carried out by means of sand pumps as previously described in the last season.

4) **Permanent Sheet Piling**

Driving the sheet piles started on 3/2/36 with drop hammers and was completed on 21/3/39.

5) **Removal of 2nd Season's Scar End**

Extraction of last season's scar end piles started on 4th Feb. 1939 and ended on 15/2/39.

6) **Concreting**

a) **Cut Offs and Toe**

Concreting the above said works began on 23/2/39 and ended on 3/6/39, with a daily average out put for the cut—off 60.00 M3 & for the toe 72.00 M3.

b) **Floor**

Concreting the foor atarted on 7th. March, 1939, and was finished on 25/4/39 with an average daily out put of 600.00 M3. The new concrete was bonded with the old concrete by the bonding bars embedded in the end of last season work.

7) **Pottery Pipes, Sumps & Grouting**

The number of cement bags used for grouting was 1170 and was carried out in the usual manner.

8) **Concrete Blocks**

Block making was started on 1/10/38 and continued till 4/12/38. The number manufactured amounted to 1217 full blocks.

Laying of the blocks started on 5th. March, 1939 and was completed on 11/5/39, with an average number of 56 blocks per day. The D.S. block apron replaced the shutters for the 2nd. lift of concrete-in-mass. The number of blocks laid this season amounted to 3077.

9) **Masonry**

Work commenced in the piers on 9/2/39, and ended on 15/6/39, when all the piers were finished up to the springing level. The procedure adopted in building all the masonry work is the same as last season.

As was carried out last season, all the piers were fitted with 4" grout holes except in pier N° 11 where observation pipes were similarly arranged.

The construction of the superstructure started on 15/5/39 and was finished in September 1939. It was executed in the same way as in the second season.

10) **Steel Work**

Erection of the C.I. grooves for the rest of the piers was completed this season, thus the whole barrage is fitted with C.I. grooves.

All sluice gates were delivered and erected, and both operating machines completed.

B) **Abutment**

1) **Excavation**

Excavation for the floor started just after dewatering the area of the main sudd of the 3rd. season have been finished and was completed on the 22nd. March, 1939.

2) **Permanent Sheet Piling**

Driving sheet piles began on the 2nd. February 1939, and ended by 8/3/39 The total number of piles driven was 788.

3) **Pottery pipes, Sumps and Grouting**

Grouting was carried out in the usual way aud 382 cement bags were used

4) Concreting

The 7 : 1 concrete - in - mass of the foundation started on 11th. March 1939 with two mixers and was completed on 29/3/39, with an everage daily output of 118.00 M3.

5) Masonry and Concrete Backing

Masonry work started by the middle of March 1939, proceeded in the usual way and was completed on 15/8/39.

Four expansion joints were constructed though none was provided in the contract.

6) Pitching

Pitching in 4 to 1 cement mortar built upstream and downstream the abutment was carried out inside the main sudd. The U.S. pitching in mortar extended to 187.50 ms. U.S. of the axis of the new Barrage. The foundation level of the toe of the pitching was gradually raised from R.L. 9.00 to R.L. 10.00 in the last 54.00 Ms. to suit the original river bed levels.

A layer of ballast was placed under the stone pitching, and weep holes were arranged in the same way as D.S. the lock.

In order to join the new pitching in mortar with the dry pitching U.S. the weir, the former was gradually raised from R.L. 10.00 to R.L. 11.00 in the last 30.00 ms. to avoid the disturbance. The existing berm for 30.00 cms. U.S. and 45.00 ms. D.S. of the weir was left untouched.

The toe of the pitching in mortar at the main outlet was raised to R.L. 11.50 to avoid deep excavation.

C) Retaining Abutment

A retaining abutment was built in connection with the old Damietta Barrage to retain the filling deposited in the ten western vents, which were to be closed.

1) Excavation

A suction dredger was put to excavate the foundation of the U.S. wing wall, and was later replaced by a sand pump assisted by a grab.

A temporary line of concrete block was placed round the site to prevent the inflow of the falling sides.

Excavation for the U.S. wing wall started on 4th. December 1938 and ended on 17th. January 1939, and for the D.S. started on 6/2/39 and ended on 11/3/39.

2) **Concreting**

A layer of 5 : 1 concrete approx. 0.60 ms. thick was deposited under water by means of skips operated by drivers, to level the floor of the old Barrage.

The foundation area to be concreted was surrounded by sand bags set by drivers as outside shutters. This area was divided into several pools by 5 : 1 concrete bags laid under water as crosswise shutters.

The top level of the cross walls so formed was left at about 0.20 ms. below the finished level and were concreted with the next pool. Rails were put over the concrete bags with their heads at R.L. 10.30 to indicate the limit and surface level of concrete. The surface of each section was floated off with a rail.

Concreting the U.S. wing wall started on 10/1/39 and ended on 17th January 1939 and that of the D.S. started on 8/2/39 and ended on 16/3/39.

The daily output was 18 ms. per day per mixer. This shortage in output was due to the long time taken by the divers in setting and levelling the concrete.

3) **Foundation Blocks**

The U.S. block work wall had seven courses of 6:1 precast concrete blocks 0.80 M3 deep, wile the D.S. wall had only four courses. The blocks were set dry under water by divers.

The work began on 20/1/39, and ended on 12/4/39, in both walls.

4) **Facing and Concrete Backing**

The filling behind the retaining abutment walls was immediately completed, up to the top of the foundation blocks in order to have a platform for building the superstructure.

The sluice gates of the old Barrage have been left in.

The walls above the foundation blocks were faced till the underside level of the granite coping with 5 : 1 precast concrete blocks, set grouted and pointed in cement mortar. The blocks were backed with 7 : 1 concrete in the usual way. Work started on 19/4/39 and ended on 22/7/39.

5) **Pitching**

a) **U.S. Side**

A row of standard Barrage apron blocks was set by divers over the floor and apron of the old Barrage to retain the rubble tipped up to R.L. 15.90, to form a toe for the dry pitching built up to R.L. 17.40. The area westward was filled up to the same level.

b) **D.S. Side**

After the completion of the D.S. Retaining Wall, a limestone rubble bank was tipped from R.L. 9.70 next the wall and R.L. 10.00 about 30.00 ms. D.S. up to R.L. 13.75 to join the new pitching in mortar.

The toe of this tipped rubble along its first 26.00 ms from the Retaining Abutment was also protected by blocks laid as in the U.S. pitching.

6) **Removal of Sudd**

Late in May 1939 a start was made in extracting the temporary piles of the sudd and in demolishing the temporary division wall at pier No 19 inside cross — struted timber sheet piled trenches. Early in August, all the piles were exctacted and the division wall was demolished.

Pumping inside the sudd was stopped on the evening of the 11th July and next day water was admitted into the area from a wide cut U.S. and from another D.S.

The water level outside sudd before breaching was R.L. 13.68 and the level of the infiltration water inside was R.L. 10.75.

The amount of spoil washed away by the water was so little that the sudd was removed later by hand to the water level and then dredged.

Before breaching the sudd all the underwater work was cleaned and inspected and all plant removed.

ROSETTA WORKS

A — LOCK

SECOND SEASON

1) **Masonry and Treatment of Crack**

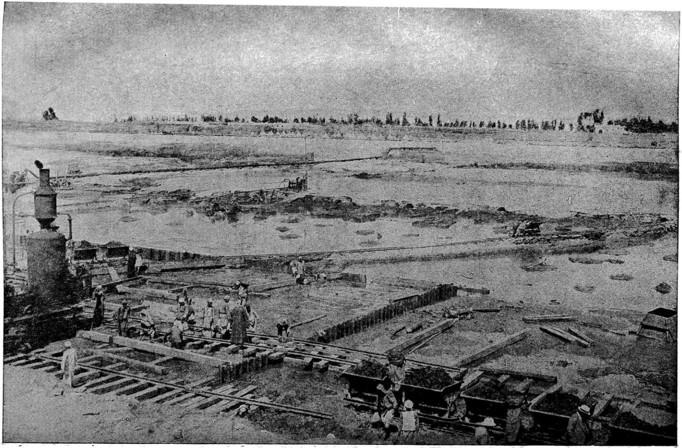
Work on the lock walls was resumed on 3rd January 1938, and proceeded slowly until it had been finished.

It took three months from the middle of March to fine dress the meeting faces of the hollow quoins, the pressure faces of the sill stones for the lock gates and the pressure faces of the temporary dam recesses. They were dressed and tested in the same procedure adopted at Damietta.



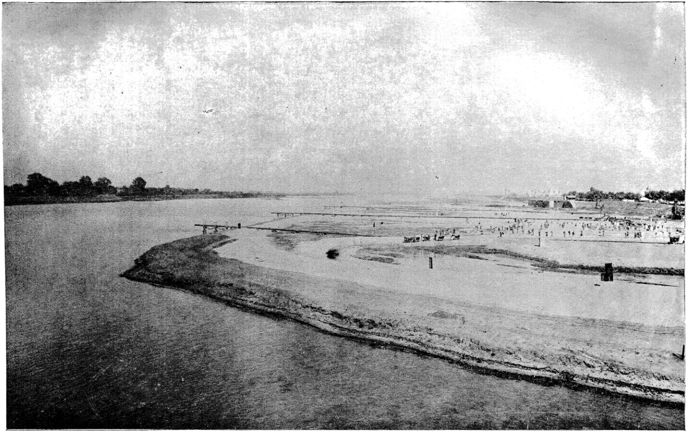
H.E. Hussein Sirry Pasha U.S. of S. during his inspecting of the work with Kamil Bey Nabih the R.E. Mr. Burkitt and Mr. Tempest.

11 - 3 - 37



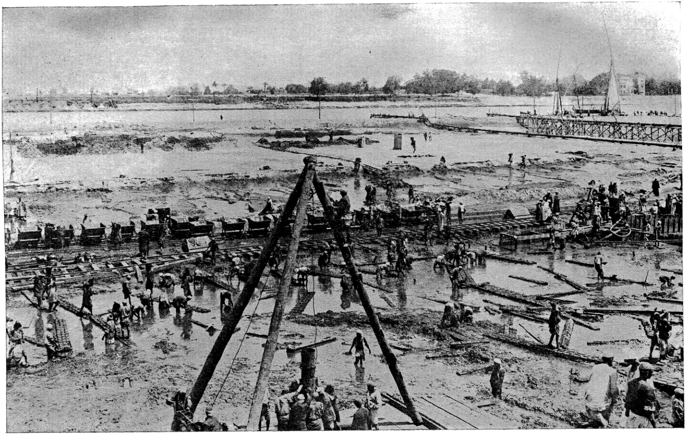
General view of site.

12 - 3 - 37



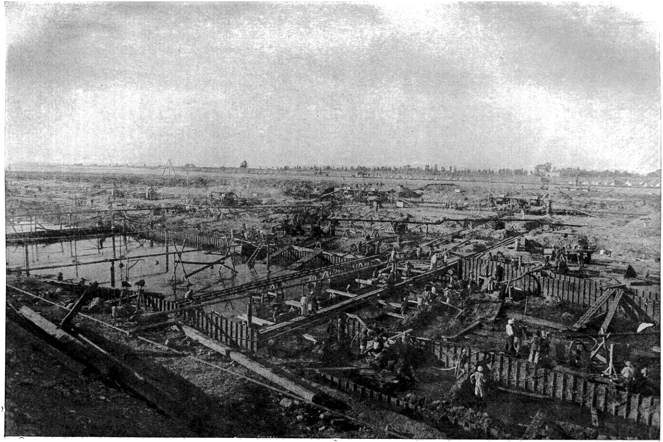
General view from the South West of the Sudd.

17 - 3 - 37



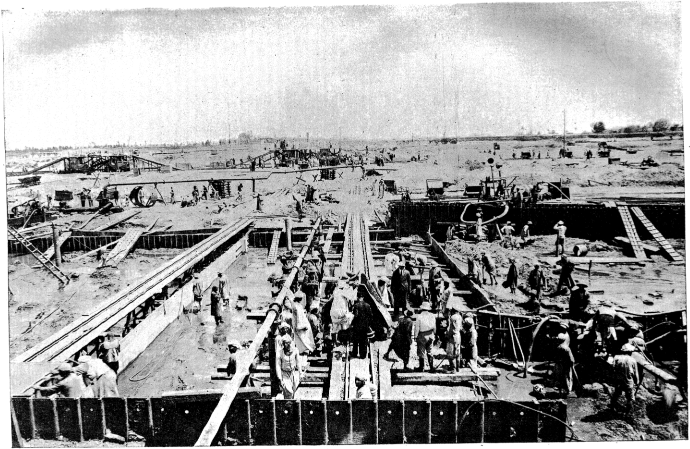
Driving well points and excavation for foundations.

12 - 4 - 37



Well points system and mixers with decauville lines
ready to start concreting.

25 - 4 - 37



Laying concrete in 1st. lift.

26 - 4 - 37



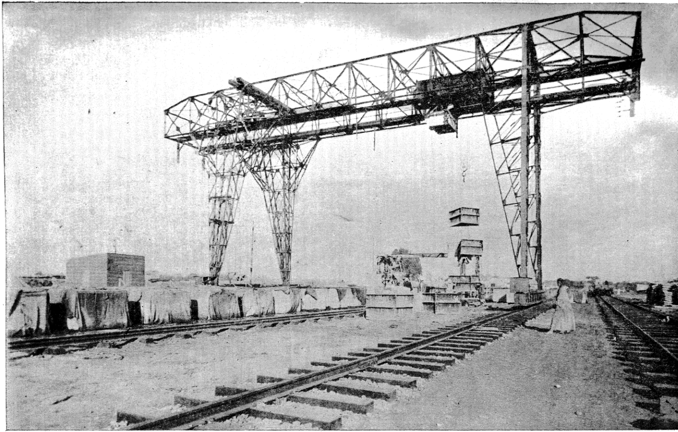
Sand pumps excavating the Cut - off.

15 - 5 - 37

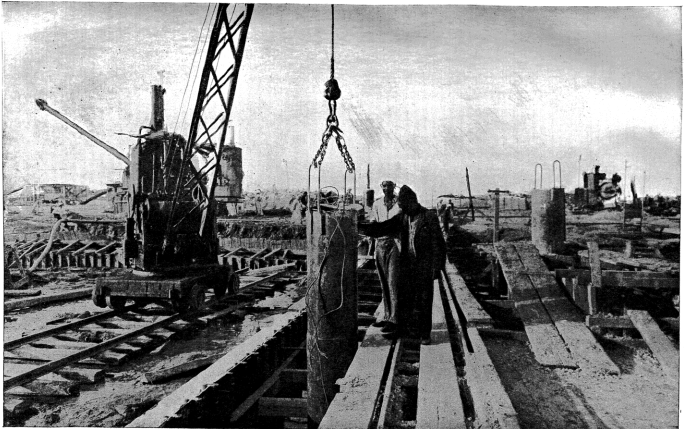


Excavation in foundations in Box No. 3.

18 - 5 - 37

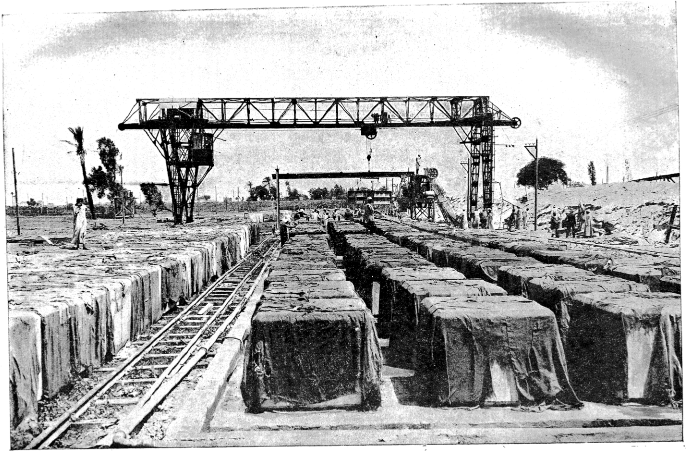


Gantry crane at work in the block yard.
19 - 5 - 37



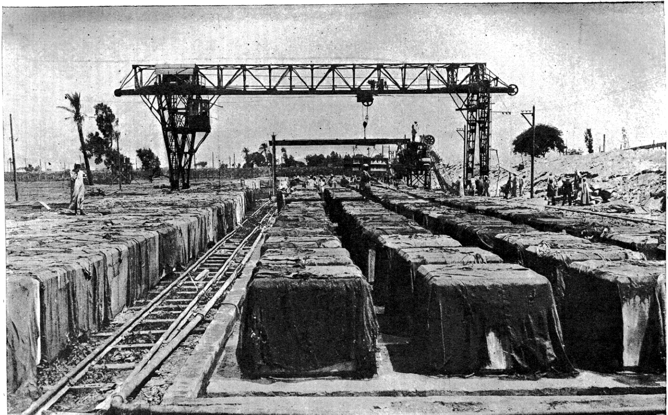
Method of concreting the Cut-off by means of special skips.

29 - 5 - 37



Block yard and stacking of blocks.

5 - 6 - 37



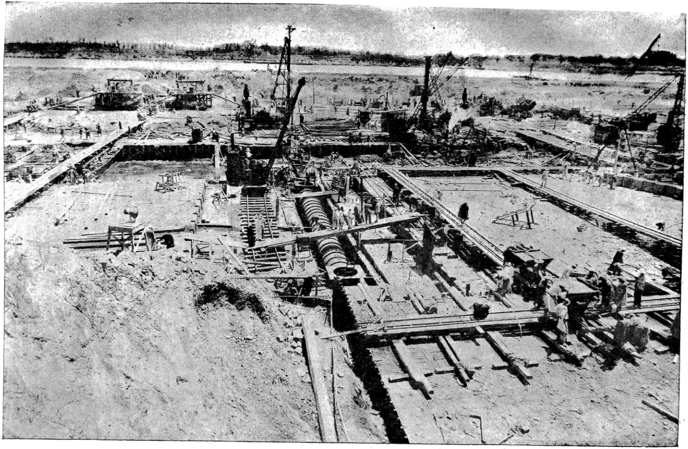
Block yard and stacking of blocks. (A)

5 - 6 - 37



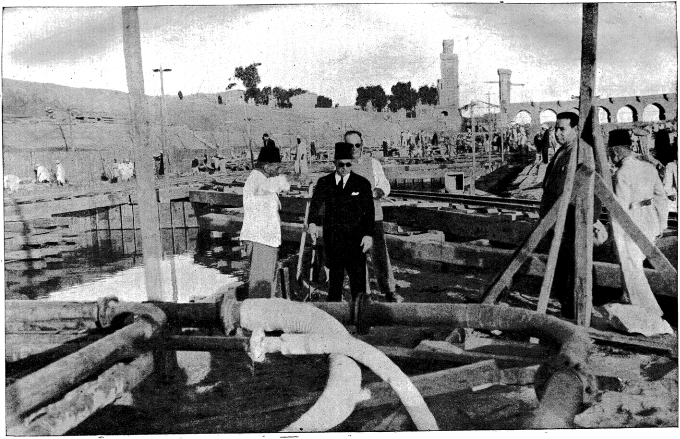
H.E. Hussein Sirry Pasha with H.E. the Resident Engineer Kamil Bey Nabih inspecting the work.

14 - 6 - 37



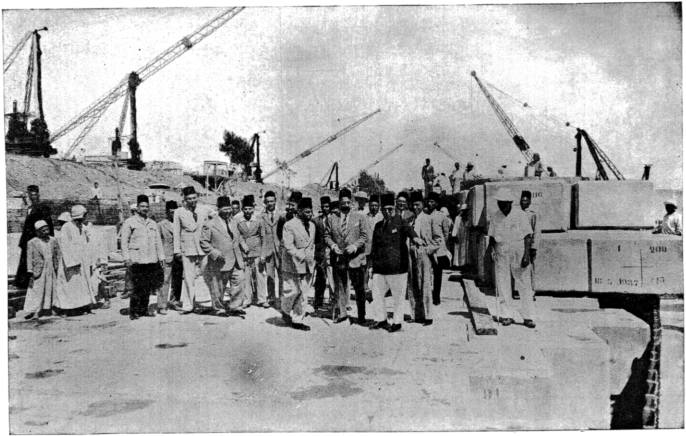
Steel tubes of subway and excavation in foundations of Barrage

15 - 6 - 37



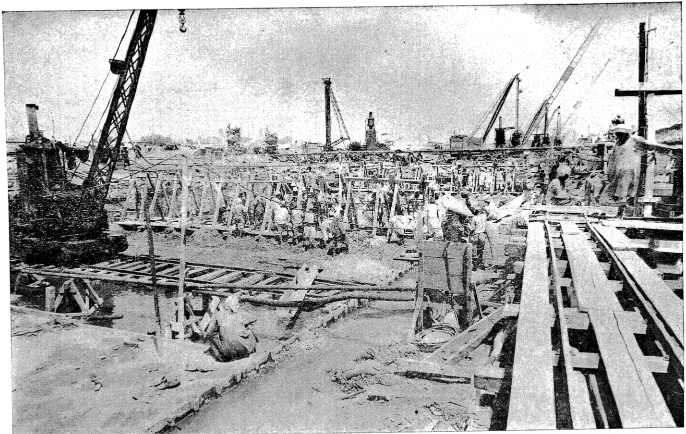
H.E. Hussein Sirry Pasha U.S. of State with
H.E. Kamil Bey Nabih R.E. inspecting the site.

15 - 6 - 37



H.E. The Minister Osman Moharam Pasha, H.E. The Under-Secretary of State, H.E. Director General of Reservoirs and H.E. the Kamil Bey Nabih Inspecting the work.

10 6 37



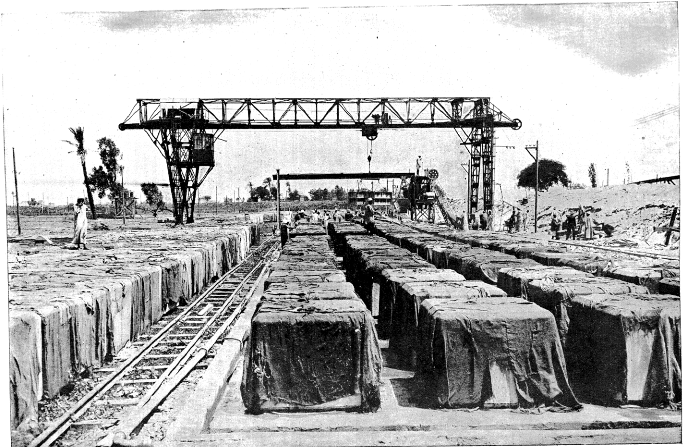
Method of excavating the two cut offs in the area of the Barrage floor east of lock.

25 - 6 - 37

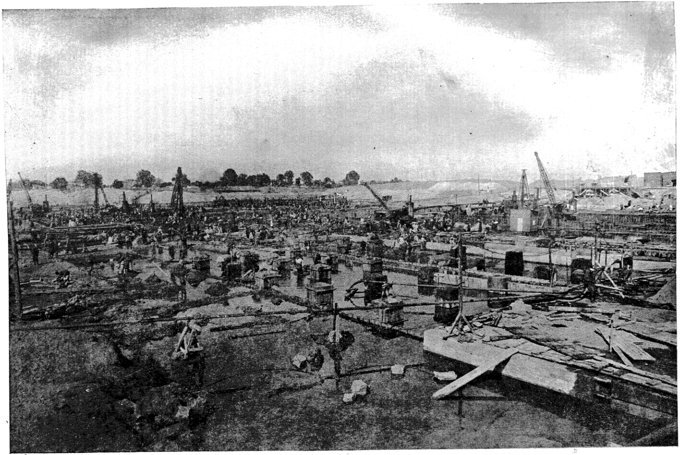


The toe of the pitching in mortar U.S. of Lock.

4 - 7 - 37

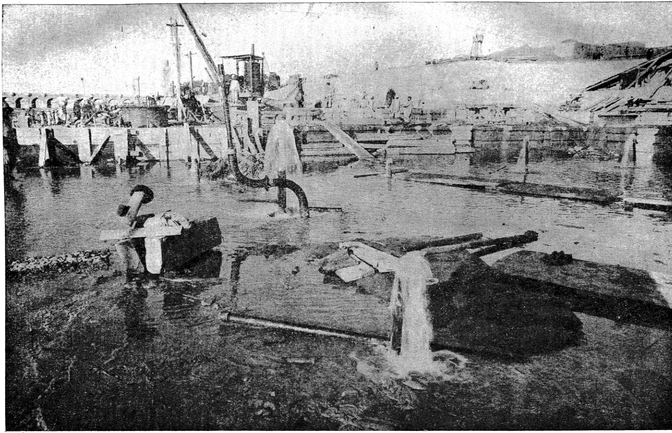


فرع دمياط — عملية الكتل الخرسانية
Manufacturing of concrete blocks, Damietta Yard.

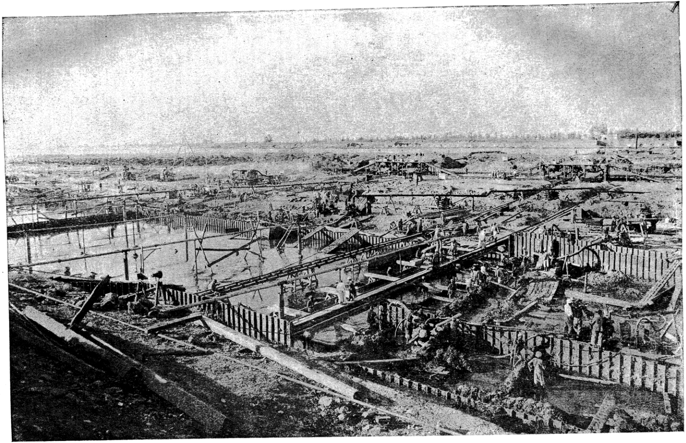


فرع دمياط — الأعمدة الخرسانية لحمل خطوط الديكوفيل المعدة لنقل
خرسانة فرش القنطرة

Concrete pillars, for carrying decauville tracks for concreting Damietta Barrage floor.

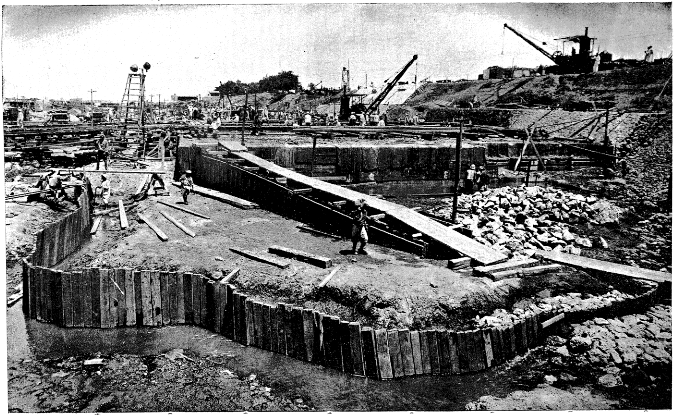


Water rushing out of grouting pipes before grouting in the area D.S. the Subway.

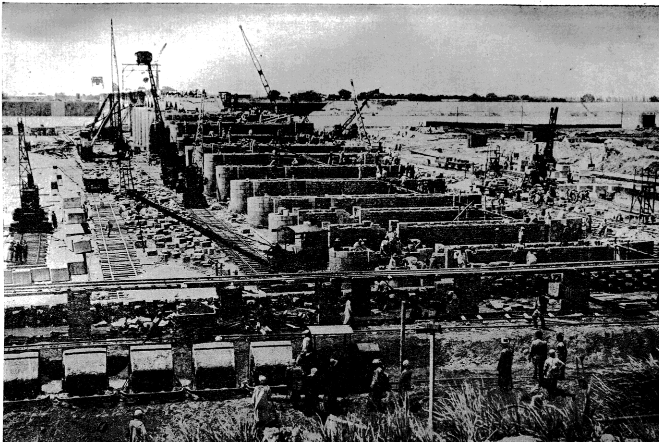


فرع رشيد — منظر عمومى لحفر أساسات الموسم الأول (طريقة الآبار)

General view of excavation first season, Rosetta,
(Well point system)

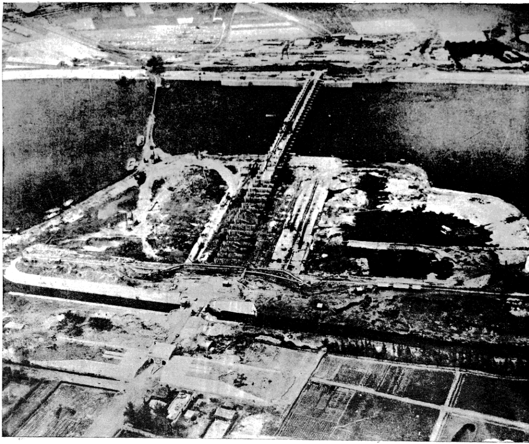


فرع دمياط — حماية نهاية ماتم بالموسم الأول
Scar end protection 1st. Season, Damietta



فرع رشيد — تقدم سير العمل بالدعامات

Progress of Rosetta piers, third season.



فرع رشيد — منظر مأخوذ بالطائرة للموسم الثالث
Airial view Rosetta Works 3rd. season.



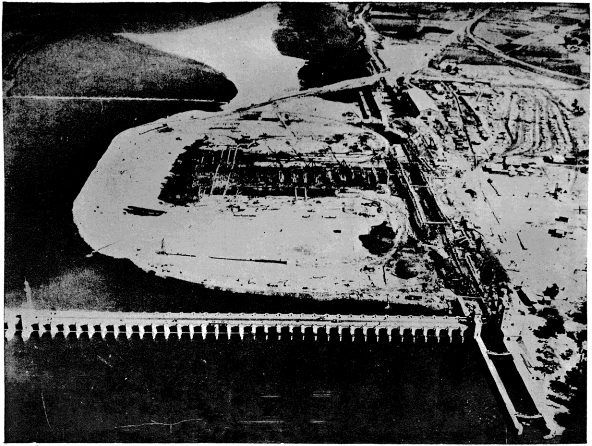
فرع دمياط – منظر مأخوذ بالطائرة للموسم الثالث

Airial view 3rd. Season, Damietta.

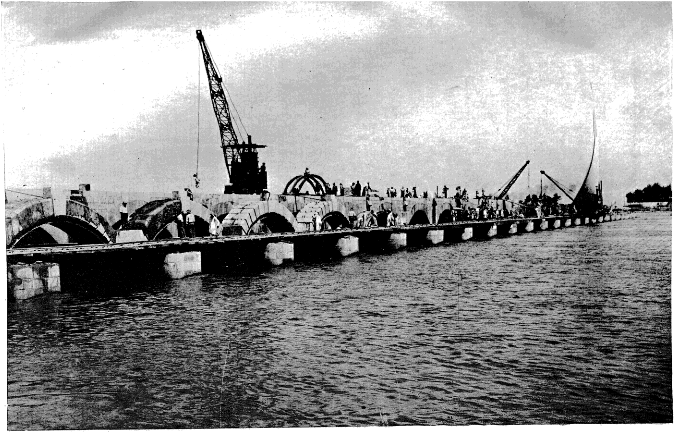


فرع دمياط – الكتل الخرسانية والهدار خلف القنطرة

D.S. Block work apron & deflecting weir complete Damietta.

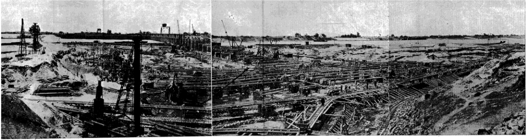


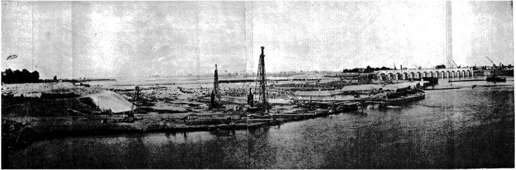
فرع دمياط — منظر مأخوذ بالطائرة للموسم الثانى
Airial view 2nd. season, Damietta.

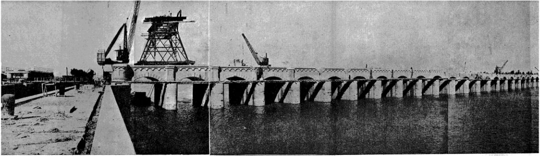


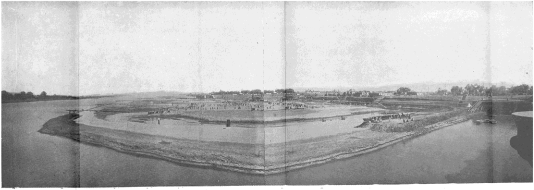
فرع رشيد — منظر أمامى للقناطر أثناء الفيضان

U.S. view of Rosetta Barrage, during flood.









فرع دمياط — منظر عمومى للسد
General view of the Sudd. Damietta.

The building of the platform for the roller paths and the radial platform to take the wedges of the bridge were finished. The bed stones were set dead level and fine axed carefully in situ. The noses of the platform and bridge abutment were completed. All the boatsteps were dressed back and their noses splayed.

Marble gauges were fixed at the U.S. & D.S. gauge wells. When the area enclosed by the sudd was dewatered and the floor was exposed, few hair cracks were observed in the floor with one principal transverse crack close to an expansion joint in the lock walls. This crack was about 8 m/ms wide when it was first discovered. The same remedial measures taken at Damietta were adopted, but as the walls of the lock were already built, the expansion joint in the floor was placed between them, also inside the culvert between the walls and in the portion of the floor outside the river wall, i.e. it was not carried under the walls.

2) **Pitching**

a) **Upstream**

The continuation of the 1st. season's work was completed to the specified limits inside a subsidiary sudd and was extended further U.S. by dry pitching till it joined the old pitching D.S. the existing Barrage. The formation level of the latter part was raised to R.L. 13.00 and the toe was formed by tipping the stones o the water level, over which the pitching was hand packed

b) **Downstream**

The pitching to the limit indicated on the Contract drawing was executed inside the sudds. The trench of the toe was excavated by sand pumps, and a rubble raft was formed, by depositing limestone into the water, about 4.00 ms. wide at the top. On this raft, a hand packed rubble toe two metres wide with a minimum depth of half a metre and surface level at R.L. 10.00 instead of the designed level R.L. 9.50, was formed.

Dry pitching was extended northward outside the sudd about 72.00 ms. but the formation level of the toe was raised to R.L. 13.00, as in the upstream side.

3) **Steel Work**

During this season the lock gates were erected complete. After dressing all the green heart timbers it was found necessary to change the heel post of the D.S. right hand gate, the latter being defected. As there was no sufficient time for it to be replaced before the flood it was agreed to have it temporarily erected and that it should be replaced in the third season.

Erection of the swing bridge was started late in August 1938 and was continued during the third season.

THIRD SEASON

1) Masonry

Work was resumed in February 1939, to complete up the outstanding works from the first two seasons.

The work was entirely completed in August 1939, by finishing the granolithic paving.

2) Grouting the Main Crack

Early in May 1939, the Contractors constructed sudds U.S. and D.S. the entrances to replace the defected greenheart log in the D.S. right gate, which was temporarily fitted last season. Opportunity was seized to grout under pressure the principal crack in the floor of the lock which took 25 bags of cement.

3) Pitching

The dry pitching built last season D. S. was extended to the weir lock. The formation level of the toe was executed at R.L. 13.00 as was done last season. The work started early in April, outside the contract area

4) Subway Lining

Lining the subway with 4 : 1 fine granite concrete was carried out on the same line as those previously described in Damietta.

B—BARRAGE

SECOND SEASON

A) Regulator

1) Sudd and Dewatering

The area sudded this season was intended for the construction of 27 vents. The sudd was formed in two stages. The remains of the 1st. seasons sudd were utilized for the 1st. Stage, enclosing an area sufficient for the constructions of 7 vents. Strengthening this sudd to the required section was carried out with earth filling excavated from the right bank and was practically finished on 10/12/37. Work on the second part of the sudd started late in December, when the question of ommitting the sudd piles was settled. The spoil used was obtained from the excavation of the right bank and foundation of the Barrage inside the 1st sudd.

The sudd was closed on 26/2/38 and strengthening it to the required section was continued and dewatering started gradually.

The following is the max. number of pumps that dealt with the infiltration water which amounted to approx. 39000 M3/day :—

2	@	16"
1	@	14"
1	@	12"
1	@	10"

2) **Permanent Sheet Piling**

Driving the sheet piles for the cut - offs, toe and the 3.50 ms. diaphragms started on 30/1/38 and ended on 28/5/38; with drop hammers in the usual way. During the driving, some clutches had creeped below the required level. This was rectified by adding extra lengths of clutches, and in very few cases, the void was caulked with lead. In all cases, the concrete was carried below the top of the joint.

3) **Removal of 1st. Season Scar End**

This was dealt with as previously described in Damietta and all piles were extracted.

4) **Excavation**

a) **Floor**

Excavating the foundation of the floor started on 1/1/38 and was completed on 24th June. The surface layer of the bed of the river inside the 1st sudd was sand mixed wish fine clay, but as the excavation went deeper or extended to the area enclosed by the 2nd sudd the bed was good fine sand. The majority of the excavation was done bv hand labour.

b) **Cut - Offs and Toe**

The cut - offs and toe were excavated in the usual way using sand pumps. Excavation started on 23/2/38 and 1/2/38 and was completed on 31/5/38 and 30/6/38 for cut-offs and toe respectively.

5) **Concreting**

a) **Floor**

With the exception of modifying the slope of the underside of the apron in view of making it flatter in order to avoid the difficulties experienced the method of concreting the floor at Damietta was adopted at Rosetta.

The scar end of the last season's floor was bonded with $1\frac{1}{2}''$ diam. bars and of 4.50 ms long. Few hair cracks developed in the 1st. lift and were treated in the same way as at Damietta. Concreting began on 12/3/38, and was finished on 24/6/38.

b) **Cut - Offs and Toes**

Concreting began by the middle of March 1938, and was completed by the middle of July. The delay was due to shortage of plant for excavation and handling the concrete materials with the result that concreting was suspended for forty days from 2nd April. To speed up the work, alternate sections were concreted first followed by the intermediate days.

The angles specified for the bearing of the bulkhead shutters were ommitted as it was found that the bulkheads could bear easily on the clutches.

7) **Grouting**

Grouting was carried out in the usual way. The number of cement bags used amount to 1902.

8) **Masonry**

Casting of 5:1 concrete floor preceded the masonry of the piers which was started on the 29th March 1938. The procedure adopted at Damietta Barrage, was followed at Rosetta for the construction of the piers, sills, lip weir, pitchers, holes in piers, observation pipes and construction of arches. Observation pipes were brult in pier No. 15. By the end of July, 25 piers were finished to the springing level and the last eastern three piers were stopped at the levels 16.90, 16.10 and 11.30 respectively.

The construction of the superstructure was started on the 5th June with the masonry of the main arches and was continued during the flood in the same manner as at Damietta Barrage. By the end of Feb. 1939, the superstructure was entirely completed to pier No 21. Eight centrings were used against four at Damietta owing to the greater number of vents to be built.

9) **Concrete Blocks**

Two kinds of moulds were used, 1.50 m. x 1.22 m. x 1.00 m. which was conformable to the specifications and were made abroad and the other kind of moulds 1.50 x 1.25 x 1.00 m. were made locally. In laying the blocks, the two sizes were kept in separate lines, so that the specified spacing should not be interfered with.

The following table gives particulars of the operation :—

	Date of		Number of	
	Start	Finish	Blocks	Half Block
Manufacture	17/4/1938	14/8/1938	4505	— —
Setting	30/3/1938	21/7/1938	5014	— —

10) **Scar End Protection**

a) **Floor**

These works were of a similar nature to those at Damietta except that a transverse diaphragm was driven permanently under the last pier No 28. The area between the scar end of the concrete and temporary piles was filled with dry limestone rubble. Also similar provisions were taken for connecting third season's sudd piles with the transvers diaphragm under pier 23.

b) **Superstructure**

The same arrangements made for stiffening the last pier for the end of the season's work at Damietta were made at Rosetta at pier No 29.

11) **Steel Work**

Erection of the C. I. grooves followed the construction of the piers of the regulator. No sluice gates were delivered this season.

12) **Cleaning Down**

Before the advent for the flood, the barrage floor and piers were cleaned, inspected, and all rubblish removed as well as all mortar droppings.

13) **Demolition of Sudd**

The breach of the sudd took place on 2/8/38, after clearing off the area from the plant.

14) **The 1938 Flood**

As a result of the experiments made on a small scale model for the best position of a stone bar to protect the bed of the river against scouring at the site of the 3rd season's foundation during the comming flood, it was found essential to construct this bar D.S. of the permanent works.

Dredging the remains of the sudd started on the 2nd. day of its breach, and proceeded during the flood until such a time that dredging was useless on account of the high river levels.

Although the flood this year was very high, yet it did not cause any damage to the new works. Soundings had to be made periodically to ascertain the conditions of the scar end and the stability of the D. S. block work apron. Such soundings showed that there was silting U. S. and scour D. S. the stone bar, but sufficiently far from the permanent work not to endanger it.

B) East Abutment

This section of the work was started late owing to the incompletion of the construction of the Nagayel regulator which necessitated keeping open the temporary diversion of the Nagayel canal for a longer time. A sudd was made encountering the area of the work.

1) Permanent Sheet Piling

The pile driving started on 22/4/38; and was finished about the middle of July. Some piles at the end of the D.S. wing wall required redriving. A dolloy was sometimes used in driving the piles to the correct levels.

Although the foundation had been practically excavated to the formation level, yet the time available was so short, the whole work was abandoned until the third season after concreting the bottom lift of the toe.

2) Pitching

300.00 and 450.00 ms. length of pitching were built U.S. & D.S. the abutment respectively. The toe was executed inside a trench partly dredged to a temporary level and completed by hand to the designed level. Sand pumps were put at the toe of pitching in mortar to assist the excavation by hand.

The toe was raised by one metre for a distance of 40.00 ms. from the tangent point of the abutment wall.

D. S. the abutment, the designed formation level of the toe was maintained in a distance of 25.00 ms. D.S. the salient angle, after which it was raised by half a metre and the pitching was built on the same lines as described for the pitching D.S. the lock.

THIRD SEASON

A) Regulator

1) Sudd

The formation of the sudd began by dumping sand bags in shallow places backed with earth filling near the east bank on 31/10/38. This procedure being slow and expensive, was abondoned and steel sheet piles were driven to form a core for the earthen sudd. The earth filling was obtained from the spoil dredged from high parts in the bed of the river at the west bank, from the foundation area to be concreted this season and from the Nagayel Bank and other sources. Driving the temporary piles started on 18/11/38 and was completed on 15/1/39.

The sudd was closed on 14/1/39 and dewatering started which at first was carried at a great pace that it caused serious leakage in the weak parts, and was therefore reduced to allow for strengthening it.

The following is a list of the sizes of the pumps used :—

1	@	16″
1	@	14″
2	@	12″
1	@	10″
1	@	8″

2) Excavation

All excavation was carried out as described in the second season.

a) Floor

Excavation for the floor started on 4th February 1939 and ended on 22nd. April 1939.

b) Cut Offs and Toe

Excavation started on 18/2/39 and ended on 8/4/39 and was carried out by sand pumps.

3) Permanent Sheet Piling

Driving of the permanent sheet piling for the cut-offs, toe, and diaphragms started on 10/2/39 and ended on 17/3/39.

4) **Concreting**

The work was carried out on similar lines as the last season.

a) **Floor**

Concreting the floor started on 13/3/39 and was completed on 1/5/39.

b) **Cut - Offs and Toe**

The actual start for concreting the foresaid works was 28/2/39 and was finished on 11/6/39.

5) **Pottery Pipes, Sumps and Grouting**

Grouting started on 24/4/1939. The number of cement bags used was 1530.

6) **Granite Masonry**

The same method carried out in the second season was adopted for the construction of piers, sills, lip weir and for forming grouting holes and observation pipes, the latter were built in pier No 30.

The construction of the piers up to the springing level and the completion of the piers at the scar end of last season was completed on 24/6/39.

The construction of the superstructure including the arches was stated on 26/2/39 and proceeded during the flood till it was completed by 17th. September 1939. Six centrings were used this season,

Concrete was lifted from the floor to the top of the piers by means of two electrical lifts, one for lifting the full skips and the other for lowering them after being emptied.

7) **Concrete Blocks**

Setting of concrete blocks forming the aprons started on 20th. April 1939, and was finished on 15/6/39. The number of concrete block laid this season amounted to 3422 blocks and 34 half blocks. Block mokin was statrted on 18/10/38 and was completed on 26/1/39 and the number made amounted to 3155 full blocks and 38 half blocks.

B) **Abutment**

1) **Excavation**

Work was started on 27/2/39 in re - excavating the foundation of the abutment which was abandoned and flooded last season. This, was completed on 22/3/39.

2) **Permanent Sheet Piling**

The majority of the sheet piles were driven to the Contract levels during the second season. The piles at the D.S. wing wall were redriven to correct levels. This was started on 21st. February 1939, and ended on 10th. March. 1939.

3) **Concreting and Grouting.**

Concreting the floor started on 28/2/39 and ended on 23/3/39, and was grouted with 402 cement bags.

4) **Masonry**

Work was started on 29/4/39 and proceeded in the usual way i. e. the granite facing in advance of the concrete backing, until the work was completed in August 1939, with the exception of the granolithic paving which was finished by the end of September 1939.

Four expansion joints were introduced.

5) **Pitching**

The dry pitching built last season D.S. the Abutment was extended to join with the existing pitching of the old weir.

The formation level of the toe as executed was R.L. 12.00 till 605.00 ms D.S. the axis of the new barrage and then sloped up to R.L. 12.70 at the weir. This work was started in April 1939, outside the sudd area.

At both sides of the abutment, pitching in 4 to 1 cement mortar was completed. The formation level of the toes was executed in the same manner as previously explained. Though the toes were completed in April 1939; yet the work in the slopes was done slowly pending the earth filling at the back.

As a result of the spur built in line with the stone bar, and against which the Contractors attention was drawn during its construction, part of the D.S. pitching in mortar collapsed. This was remedied by dumping stones at the toe and undermining the collapsed part and rebuilding it in short lengths and grouting it later through pipes left in purposely.

A small line of temporary sheet piling was driven across the D. S. dry pitching, to stop percolation water finding its way behind the pitching in mortar near the collapsed area.

In May 1939, the subsidiary sudd made specially for the dry pitching U.S. the nose of the new entrance to the Nagayel canal, was constructed. Owing to the accumulation of limestone rubble tipped as a protection for last season work, it was impracticable to confine the area with timber piles, so the formation level of the toe was raised from R.L. 9.50 to R.L. 12.00 with a slope 1:15. This pitching was continued U.S. to join with the masonry revetment D.S. the old Barrage.

6) **Mosaic Pitching**

The banks at the back of the lock and abutment above R.L. 19.50 were pitched with limestone built in 4:1 cement mortar faced mosaic with a saddle back limestone coping in random lengths varying from .50 m to 1.00 m.

The work started late in September 1939, and was completed in November 1939.

7) **Steel Work**

Erection of the C.I. grooves was completed in the remaining half of the barrage built this season.

All sluice gates were delivered and erected as well as both operating machines.

The swing bridge was completed and the heel post of the D.S. right hand gate was renewed.

8) **Cleaning Down**

Before the arrival of the flood, the Barrage and abutment floors were cleaned and carefully inspected.

9) **Demolition of Sudd**

On 15/5/39, the extraction of the temporary piles in the sudd was started, and was completed by the end of June. In the early days of June 1939, the demolition of the two temporary walls started and was completed with the final extraction of the piles.

All plant and tools were removed and the site cleared and the sudd was lightened by hand to the water level and was then breached on 26th. July 1939.

BEHERA CANAL AND REGULATOR

1) Site of Regulator

As a result of the borings carried out by the Contractors at the Contract site on 30th, July 1937 which revealed that the reliable sand stratum existed at R.L.+7.00 except two spots which were at R.L. + 4.00 while the designed formation levels varied from 7.50 to 8.50, a series of borings were carried out as proposed by the Contractors at a new site 210 m. D.S. These borings showed that good sand existed at R.L. 7.00. Before final decision was made, the two low level points, at the original site were checked and were found incorrect and the new site was therefore abondoned.

Although the Contractors undertook to drive a ring of temporary sheet piling round the site, yet they have gone in the expenses of several trials without success, to do away with them. They tried two test pits one of them was of the dimensions 40 × 38 ms. while the other was 25 × 25 ms. and both were sunk to a depth of 7.50 & 4.50 ms. respectively. Pumping started in the first pit with one 6" pump when the infiltration water was at R.L. 15.55. Springs bursted out as soon as the water level began to drop, and water level was again raised. The number of pumps was then increased gradually to a total of seven of the same diameter, but springs bursted violently carrying blackish material, causing the ground in the vicinity to crack. This gave a concrete evidence that the subsoil had a treacherous stratum.

2) Excavation

On 17th. November 1937 the Contractors started to excavate for the lock, and the abutment at the contract site, but the subsoil water showed itself at R.L. 15.00

As the infiltration water was excessive, the Contractors proposed to dewater the whole site by a ring of filter wells. As a trial they sunk a circular masonry well 3.00 ms. in diameter partly by hand from R.L. 14.50 to R.L. 11.50 and partly by an electric shovel down to R.L. 0.66, although the surrounding subsoil water was at R.L. 13.80. In the vicinity of the well four 2" pipes, each 12 ms long were located with their bottoms at R.L. 2.50 for measuring the levels of the subsoil water. The well was equipped with three pumps, two 6" and one 8". One of the 6" together with 8" pumps were fixed on a platform inside the well at. R.L. 8.00 to avoid long suction and inspite of keeping one of the 6" pumps running all the time the water level never dropped below R.L. 6.50.

This proposal was given up and replaced by three temporary sumps outside the limits of the permanent work, and with ample pumping, it was able to go down with the excavation to R.L. 12.00 by hand in the dry.

The different strata of the subsoil recorded in sinking the filter well is tabulated thus :

Levels		Strata
from	to	
+ 14.50	12.50	Loam
12.50	8.50	Plastic clay
8.50	7.00	Flowing silt
7.00	4.80	Sand mixed with some gravel
4.80	0.66	Sand mixed with more gravel

As it was difficult to proceed with excavation below R.L. 12.00 by hand, three 8" sand pumps were installed to pump out the flowing silt.

3) Temporary Sheet Piling

The area of the work was encircled with Augree Sheet piles 12 ms. long driven down to R.L. 4.50 to enable proceeding with excavation to the formation level.

The piles in some places leaned forward under the outside load, and were therefore tied back from the top with steel wire ropes to anchors securily buried in the ground. When the concrete floor had been grouted and masonry works advanced, these piles were extracted.

Driving was started on 3/4/38 and completed 9/5/38.
Extraction began on 10/11/38 and was completed 22/1/39 .

4) Permanent Sheet Piling

When excavation reached R.L. 9.50, on 12th June 1938, driving of the permanent sheet piles started and was completed on 3/8/38. As sand existed below contract levels, certain modifications were made in the levels and lengths of the piles to ensure a good penetration in the sand stratum, to assist their stability.

5) Subsoil Water

The site being in close proximity to the Rosetta branch, the existing Behera Canal, and the Pond at Galatma Village, the subsoil was undoubtedly heavily water logged. To avoid heavy pumping it was suggested to complete all excavation work for foundation during closure period, but as it was inadviseable to restrain the Contractors efforts, they were allowed on their request to lay the concrete foundation during the flood when all their plant from Rosetta & Damietta works were released on condition that:

1—Ample pumping should be provided and well maintained.
2 - All uncapped piles to be tied and roughly capped, so as to seal the concrete fondation when grouting.

To ensure that the concrete raft was not subjected at any time to a head that might cause damage, a thorough information of the behaviour of the subsoil water was studied: Five 3" gauge pipes were sunk on either side of the temporary sheet piling surrounding the site. The recorded levels revealed that these piles, caused a drop in the hydraulic gradient of 2.00 ms. when the site was drained to about R.L. 7.00 and of 1.00 m when water was maintained at the main sumps at R.L. + 9.00.

The maximum quantity of infiltration water dealt with amounted to approximate by 4500 M^3 /hour, viz. 108000 M3/ day. The following is a list of the pumps used:

1	@	16"
2	@	12"
10	@	8"
1	@	6"
2	@	5"

Between Ist. and 15th. September 1938 - namely - before sealing the sumps in the floor, the total number of pumps used on the works inside and outside the floor area amounted to 69 of which 11 were kept as a stand by.

6) Subsidiary Sumps and Pottery Pipes

Sumps and pottery pipes were located as explained in the Barrages but it was found necessary to increase the number of pottery pipe lines to cope with the excessive infiltration water.

7) Concreting

a) Lock

Concreting the lock floor started on 24/8/38 and ended on 19/10/38 It was laid in three layers on the same procedure as the barrages.

b) Subway and Toes

Concreting began on 15/8/38 and was completed on 3/10/38 and was laid in two layers. The foundation of the subway was lowered 30 cms than originally designed.

c) Regulator

Concreting the main raft began on 6/8/38 and ended on 25/9/1938 and was laid in four lifts.

d — **Abutment**

The foundation of the abutment was laid in three lifts. Concreting started on 30/7/38 and ended on 24/9/38.

8) Grouting

When concreting the foundation was completed by 25th. Sept. 1938 it was found safer to postpone the grouting operation until a later date owing to the high subsoil water levels and therefore the vertical grouting pipes were either prolonged or bent to enable masonry to proceed. The subsidiary sumps were completely sealed by the end of October 1938 which work was started by the end of September, and grouting was then started as it was definite that the river levels were continually falling, and was completed on 18/1/39. During grouting, the water level in the main sumps was maintained at R.L. 9.00, but in certain cases when grouting external sections of the foundation, the water level was allowed to rise to R. L. 10.00 as in these cases a small amount of grout was noticed to extrude from the foundation piling. This was stopped by using thicker grout 1:3 instead of 1: 4. The process of grouting the floor was carried out in the usual way and similar to the Barrages.

The number of cement bags used amounted to 4190

9) Crack at Lock Foundation

Early in November 1938, when masonry in both land and river walls of the lock had been brought up to R.L. 12.30 and 11.50 respectively the floor of the lock had cracked through the whole width about 40 ms. upstream the axis of the regulator. The following treatment was carried out in due time:

1 - An expansion joint with standard copper seals was placed in each wall of the lock over the crack.

2 - The floor along the crack was cut into a wedge shaped section of following dimensions:

Top width	=	1.00 mt.
Bottom width	=	1.20 »
Depth	=	0.70 »

Holes were drilled at both sides of the trough 1.50 mt. apart in which bonding rods 1.25" mt. long and 1.25" diam. were fixed with neat cement. Before levelling the bottom of the trough with 2: 1 cement mortar all the water comming through was lead in a small trough to a sump near the land wall where two 3" pumps were erected - one as a stand by. A standard expansion copper plate was placed in the bottom of the trough overwhich a steel trough of rectangular section was placed. The whole trough is filled with 4: 1 concrete in two longitudinal

sections. Grouting under 30 lbs/□" pressure was done after sealing the sump through pipes passing through the steel gutter and copper plate. As the part of the lock floor cast of the river wall was not cut down its top surface was caulked to avoid leakage of grout. The total quantity of cement used in grouting the crack amounted to 36 bags. For location and treatment of crack.

10) Masonry

All masonry works including the internal lining of the subway tube and shafts were executed on similar lines and order as at both Rosetta and Damietta Barrage. In the contract no expansion joints were provided, but were later introduced where change of section took place.

Work started on 22nd. September 1938 and ended with granolithic paving on 11th. December 1939.

11. Block Work Aprons

The flowing silt at the block aprons both U.S. & D.S. the Regulator was removed and replaced by sand up to the formation levels, over which the blocks were laid on a bed of limestone rubble as specified. The work started on 24th. October 1938 and was finished on 1st. January 1939.

12. Pitching

An extensive revetment of limestone was carried out on the banks of the Behera Canal, both U.S. & D.S. the regulator and also on the key between the old and the new Canals.

Work started on 24th. December 1938 and ended on 1st. January 1940.

I. Dry Pitching

No difficulties were experienced in excavating the toes as the flowing silt was removed when excavating for the foundation inside the area surrounded with the temporary sheet piles. Excavation outside this limit was somewhat difficult owing to the bursting of springs laden with silt every where causing subsidence of the banks.

To reduce these difficulties and to enable proceeding with the work in the dry, the formation level of the toe was raised up to R.L. 10.50 beyond the 100 ms. U.S and D.S. the Lock and the 30 ms. U.S. & D.S the Abutment.

In order to support the toe of the pitching in mortar both U.S. & D.S. the lock, a line of permanent steel piles 5 ms. long was driven under each toe.

Inspite of raising the toes to R.L. 10.50, springs continued to burst out causing the banks to crack and small isolated portions of the already built pitching subsided and had to be rebuilt.

II. Pitching Under Water

a) **U.S. The Regulator**

To avoid the difficulties resulting from the outburst of springs during the excavation for the toes, it was agreed to construct the berm at R.L. 14.50 with 4 metres width, and to build in the dry the top portion of the pitching, together with two metres as a toe.

When water was admitted into the diversion, excavation for the lower portion was carried out by a suction dredger and rubble was then tipped under water. During the closure period when the water level receded to R.L. 14.00 all the exposed rubble was handpacked to correct levels and slopes.

b) **D.S. Regulator on the Key Between the Old & the New Canals**

The stone bar was carried out up to R.L. 16.80 in four terraces formed of rubble tipped under water from calibrated boats. Earth filling behind each terrace was first carried out to the designed profile before dumping the stones.

During the closure period the exposed face above water level in the canal was handpacked to the correct slope.

c) **Bank Across the Existing Inlet af the Old Behera**

Rubble was tipped under water to R.L. 16.00 from calibrated boats and earth filling was deposited behind it in layers 30 cms. in thickness.

The exposed area above the lowest water level was trimmed to the correct level and slope, during the closure period.

13) Breach of the Nile Bank

The Nile bank across he entrance to the new Behera diversion was breached on 22nd. May 1939. The water level in the Rosetta branch was 15.75 and the bank was gradually reduced by a drag line on the top. The bank was refilled and dewatering proceeded day and night. On the 4th. June the work was resumed on the lock. No loss of life occurred and some delay only affected the construction of the lock gates and the completion of the sluice gates.

14) Rewatering

Water was admitted in the new diversion from the D. S. end on 27th July 1939 and the U.S. bank was breached by a bucket dredger on 30th July. Two

bucket dredgers one U.S. and the other D.S. worked in widening the cuts at the two ends of the diversion to the extentnecessary as would be sufficient for passing the required discharge before closing the old canal.

15) **New Diversion**

a) **Excavation**

Owing to the fact that the bed level of the existing canal D.S. the new diversion was at R.L. 11.50, the bed level of the new diversion was agreed to be raised to that level instead of the specified levels R.L. 10.50 U.S, and 10.85 D.S. and excavation was carried out by hand in the dry. Both the U.S. entrance and the junction between the new diversion and the old canal was dredged later when water was admitted.

b) **Filling the Old Behera Canal**

The old Behera Canal was filled with materials from the following sources :

a) Spoil dredged by bucket dredgers & transported by barges.
b) Spoil dredged by suction dredgers discharging directly into the old canal.
c) Spoil stacked from hand excavation & transported either by rail or by native boats.
d) Surplus spoil after dressing the left bank D.S. the old regulator.

The work started on 1.8.39 and was completed on 1.1.40

16) **Steel Work**

a) **Sluice Gate and Operating Machine**

The erection of the six sets of groove casting started on 11.3.38 and was completed in two weeks on the same lines as the Main Barrages.

Erection of the sluice gates was done on the floor under the sluice wells using a five ton travelling derrick. Assembling started on 21.3.39 and the work continued until 22nd. May when the whole area was flooded owing to the breach of the Nile Bank. It was again resumed on 5th, June and on 28th. inst., a start was made for lifting the gates from the floor to their final position in the vents.

b) **Lock Gates**

Erection started on 31.3.39 and was completed on 6.7.39.

c) **Swing Bridge**

Erection started on 3.5.39 and was swung on 31.8.39.

TEWFIKI REGULATOR

The reconditioning of the Tewfiki Regulator consists of :—

1) Raising the floor by about 60 cms., constructing a weir in each vent togethcr with a lip and a baffle weir D.S.

2) Cutting away the end of the east D.S. Lock Wall and extending the guide pier.

3) Widening the roadway over the Regulator by extending the arches and modifying the piers and D.S. parapet.

4) Providing new sluice gates and grooves.

5) Providing a new swing bridge to replace the old lift bridge.

8) Providing new lock gates instead of the old gates.

All the under water masonry work was carried out during the 1937 - 1938 closure period while the sluice gates and lock gates and other works were executed during the 1938-1939 closure period and consequent months. A sudd was therefore necessary only in the 1st. season while the erection of the steel work was carried out between stop logs and the area dried out by pumps as will be described later

1) **Sudd**

The formation of the sudd started on 25th. December 1937 and was finished on 6th. January 1938. A gravel filter was formed at the toe to stop the movement of the sudd material by seepage water. The sudd was constructed abutting directly on the existing dry pitching at the sides of the entrance.

The sluice and lock gates were closed during the construction of the sudd and to compensate for their leakage three pipes were laid in the sudd for regulating the head.

2) **Dewatering**

The site was dewatered by means of one 12" pump as soon as the sudd was completed.

3) **Existing Floor**

Most of the toe of the D.S. pitching was demolished and replaced by concrete to R.L. 11.40. Grouting pipes of 3" diam. were found at each vent which indicated that the floor had been previously grouted. A crack 2m/ms. wide was detected at the end of the floor D.S. the lock.

4) **Springs**

Springs of small order appeared in the solid floor and were easily dealt with, except one spring which appeared in the eastern vent and was grouted with cement under pressure.

Some other springs bursted in the bed of the canal and caused the U.S. right bank to crack. When these were surrounded with sand bags, no more cracks were detected.

5) **Reconditioning of the Floor**

Work began as soon as the floor had been cleaned. A baffle weir additional to that shown on contract drawing was built at a distance of 5.16 D.S. the end of the piers to reduce the scouring effect of the water.

The existing floor just U.S. this baffle weir was cut down to receive the paving pitchers as it was higher than the correct formation level. Springs which appeared during demolition were dealt with by injecting cement in pipes laid over hem.

6) **Extension of Guide Pier**

As ths existing structure was founded on concrete cylinders, and as part of the extension of the guide pier would be founded on uncertain foundation, it was found necessary to make grillage foundation 8 x 8 ms. of old decauville rails embedded in 1:5 cement concrete.

As it was found impracticable to use special bricks, the extension was considered as an independent work, having its quoins and courses as nearly as equal as the old work, and ordinary size bricks were built between the ashlar quoins. As the Contractor failed to supply a good quality of ordinary bricks, the latter were replaced by wire cut bricks without extra cost.

The concrete hearting was also replaced by wire cut bricks. The brick work between the D.S. heel post and the D.S. stop log groove as well as the ashlar at the U.S. stop log grooves down to R.L. 15.40 was found to be worn out. The former was demolished and rebuilt and the latter was replaced by new ashlar.

7) **Extension of the Piers**

Extension was brought up to 15.60, but due to shortage of radial bricks the work was held up before the end of the closure period.

The part of the ashlar of the inner faces of the U.S. stop log grooves of the vents that was found to be worn out was demolished and rebuilt in sornaga bricks.

8) **Demolition of the Sudd**

On 5.2.38 the three pipes in U.S. sudd were opened until the water had covered the floor of the regulator to sufficient depth and the sudd was then breached. The remains of the sudd were later washed out by the water.

9) **Extension of the Arches**

The width of the vents when measured was found to differ slightly from the assumed width 5 ms.

Timber centrings were used and the work proceeded in the usual way by building first the limestone vousoirs and then depositing the 4:1 fine granite concrete in three segments as was carried out in the main Barrages.

This work was started in December 1938 and ended early in February 1939.

10) **Superstructure**

The 8:1 filling, parapet walls, cope stones of both regulator and lock, granolithic paving and asphalt brick proceeded in the usual way till completion.

11) **Pile Foundation for the New Swing Bridge**

The two borings made at the site of the bridge raft showed that the specified length of piles of 10 ms. was not sufficient. As sand showed itself at R.L. 6.50 and R.L. 5.80 and the material above being unsuitable for finishing the toe of the piles, they had to be made 15 ms. long.

As soon as the foundation raft was excavated, work started in driving the reinforced concrete piles. All piles were successfully driven without water jetting, Only one pile was casted in rapid hardening cement and put in use at 14 days age to replace another damaged during handling. The top of the piles was stripped off and the steel spread at an angle 60° to the vertical. Reinforcement was fixed and concreted in the foundation raft by the lst. week of June 1939.

12) **Limestone Ashlar**

This was brought from Tabaket Ahgar El Shawish quarry and dressed at site. A certain number of the old stone were redressed and used in the works.

13) **Steel Work Survey**

The joint survey made in the closure of 1937-38 for the Tewfiki grooves and overhead gears showed that they were badly worn out and unsuitable for the travel of the new gates, thus new grooves had to be ordered and also a new operating machine.

14) **Sluice Gates**

Early in December 1938, all the top sections of the old grooves were dismantled and the masonry between was cut away to the extent required and holes for the new grooves drilled in the exposed parts. Later, during the closure period, timber stop logs covered with tar pauline were placed upstream in all vents and the first baffle weir heightened with sand bags, and water was maintained well under the level of the sills by continious pumping. The remaining bottom of the sections of C. I. Grooves were then dismantled and masonry recesses cut away to receive the new grooves and holes drilled through the piers. Erection of new C.I. Grooves, dressing of sills under the sluice gates and placing of new gates in position, and operating machine were all completed by the end of January 1939.

15) **Lock Gates**

Examination of the lock gates was made when the lock was dried during the closure of 1937 - 38.

The contract dimensions and reduced levels were then checked and corrected.

It was found that new cast steel heel pivots had to be supplied so as to ensure a perfect alignment with the new top cast steel anchorage blocks which would be supplied. The projecting strips in the C.I. hollow quoins were found worn out and had to be patched and dressed to a true surface before the new gates being fitted,

Late in December 1938, the lock was sudded with timber stop logs and then dried after removing the old lock gates. Dressing and grinding the existing C.I. hollow quoins and sills started in January 1939 and proceeded until late in April 1939 when the lock gates were swung and tested. Water was admitted in the lock on 22nd April 1939 and was normally used by the end of April.

The old lock gates and operating gears were removed and replaced by new material of practically the same design except for the operating gears of the D.S gates where the winches had to be moved further D.S. to clear the swing bridge.

Some trouble was experienced with the operating gear of the right hand D.S. gate and was rectified by moving the quadrant and arm further from the heel post during the 1939-40 closure period.

16) **Swing Bridge**

Erection started on 9th. March 1939 and the bridge was swung on 13th. June but was entirely completed and opened to traffic on 24th. August 1939.

On 17th. October 1938, the road traffic across the regulator was diverted to a one way temporary bridge spanning the U.S. ends of the piers in place of the passerelle - which had to be dismantelled and a lift span across the lock. The portions opposite the vents were made easily removeable to obtain access to the U.S. stop logs used in the erection of the new sluice gates.

NAGAYEL REGULATOR

1) Design

As the new regulator had to be built in place of the old moat bridge which had to be demolished, and as it was necessary not to interfer with the water down the existing canal during the construction of the new regulator, it was essential to pass all the discharge into a temporary channel constructed round the west side of the proposed new site of the Reg. This was made during the closure period of 1937 - 38 with a bed level R.L. (13 65), bed width 6.00 m. and side slope 1:1.

The whole foundation is surrounded by 5.00 m. mild steel sheet piling of he same type used in the Barrages. Another line of M.S.S. P. 3.00 m. long is driven 1.50 m. upstream the axis of the regulator.

2) Excavation

The excavation for the foundation of the reg. was carried out during March & Aril 1938. The new entrance was partly excavated in January 1938 and later completed in January 1939.

3) Sheet Piling

Pile driving was started in February 1938 and was completed by the end of April.

4) Floor

Concreting the floor was done in two lifts each one metre deep and was carried out between April and middle of May 1938, the seepage water was collected through pottery pipes in the usual manner and the number of cement bags used for grouting amounted to 48.

5) Construction of the Walls

Building the walls was started soon after the completion of the floor but was intermittently proceeded with. It was not until the C.I. grooves and lintel beams were built that the work was resumed in casting the concrete of the curtain wall and the arches. Early in March 1939 the superstructure was entirely completed.

6) Pitching

The pitching both U.S. & D.S. the regulator was built before the construction of the regulator when the canal was diverted. The pitching of the new entrance was carried out in two stages :-

a) The west Part was built together with the pitching of the Rosetta east bank in the summer of 1938.

b) The east part was built together with the remaining pitching of the canal in 1938-39 closure period.

7) Steel Work

By March 1939 the regulator was fitted complete with C.I. groove sluice gates and operating machine etc.

ANCIENT GATEWAY

1) Programme

The work in reconditioning the Ancient Gateway was carried out in a very slow manner and was held up for several months after being in hand. Although it was started in January 1938 as outlined, yet it was completed in October 1939 instead of the middle of April 1938.

2) Mounds

On each side of the Ancient Gateway a mound to the shape of the old fortification had been formed with selected materials from the axcavation of the Nagayel works. The side slopes have been pitched with dry limestone 50 cms. thickness and steps built in 4:1 cement mortar have been formed thereto. Runnels were formed in the west face of the mounds for catching the surface water that drains from the roof down to the toe of the mounds.

3) Reconditioning the Masonry

The existing roughly built stone, and the blank wall blocking the western end of the southern archway were removed. The existing bay in the middle of the west elevation was taken down and was rebuilt with new bricks after laying a new concrete foundation. The wall in the central archway in the rear of this bay was dismantled but not rebuilt. Most of the worn out stones of the merlons of the

parapets, ornamental capping, the coping for the tops of the retaining walls, as well as other damaged ashlar stones, were removed and replaced with new stones of exactly the same pattern.

4) Brickwork and Pointing

All the face of the brickworh masonry was raked and pointed with 1:1 cement mortar. The joints of all the ashlar stones were also raked and pointed with white cement.

5) Concrete on Roof

The roof was thoroughly cleaned and filled with 10.1 concrete in mass up to the level of the tops of the existing flights of steps, and was ramped up and finished off level with the top of the footway of the parapet.

ROADWAY BRIDGES

1) Design

Two reinforced concrete bridges of the same design were constructed on the experimental channel and the Darawa Canal for crossing the new main road between the Barrages. The bridge being built on the skew, have a net span between the abutments measured at right angles 8.00 ms.

The foundations of the abutments and wing walls were constructed of 7 : 1 concrete in mass deposited in the dry inside mild steel sheet piles of the same type as in the Barrages. The piles are 5.00 ms. long and every other pile was tied back to the concrete by 1¼" diam. tie bolts with mild steel washers 5" x 5" x 3/4".

The abutments, wing walls, and superstructure were constructed of 7 : 1 concrete faced with granite on the same lines as the superstructure of the Barrages.

As the roadway and footpaths on both bridges were to be constructed in a similar manner to the main roads, the space between the parapet wall was filled solid with materials for the excavation, rammed and consolidated before laying the concrete kerbs, hard core bottomnig etc.

2) Bridge on Experimental Channel

Excavation for the foundation was started by the middle of Jan. 1938, and the bridge was entirely completed by the end of Feb. 1939. The only point worth mentioning is that the first timber forms for the concrete deck deflected about 3 cms. When tested and were therefore strengthened by rearranging the main and subsidiary strutting.

3) Bridge on Darawa Canal

Although the work in executing the bridge was started by driving the mild steel sheet piling on about the middle of March 1938, yet, it was not entirely completed except early in April 1939. As the canal was running in turns, the foundation of each abutment was surrounded by a temporary sudd leaving an ample section of the canal for the discharge to pass. After several suggestions for supporting the forms of the reinforced concrete slab, it was decided to stop execution until the flood is over. In November, wooden trusses to support the framework were constructed during the low water turns in the canal, and seeing that these deflected about 8 cms. when tested, the work was stopped until the closure period when the trusses were strengthened, supplementary support was given to them by timber sole pieces on the bed of the canal.

Both reinforced concrete bridges were concreted to the underside of the deck which was in turn concreted in one continuous operation. Care was taken from the beginning in rendering the framework grout tight.

HYDRAULIC RESEARCH LABORATORY

1) Experimental Channel and Main Intake

The hydraulic research leboratory is to be supplied with water necessary for experiments to be conducted there in, from the river, through an open channel by means of an intake at 150 ms. U.S. the New Damietta Barrage. This intake consists of twin culverts of reinforced concrete seigwart pipes of 2.00 ms. diam. each resting on 7: 1 concrete in mass, and having two masonry heads. The inlet to the culverts is provided with two large cast iron sluice valves fitted with cast iron bell mouth and the outlet has cast iron bell mouths of the same type.

2) Drain to Darawa Canal

This drain is formed of a line or reinforced concrete seigwart pipes one metre diam. with masonry heads at both ends and a manhole at the middle. Its main function is to drain the seepage water from the experimental channel during the period of high Nile.

3) By—Pass Inlet

A 2.00 m. diam. reinforced concrete pipe is laid from the Damietta Abutment to the Control Chamber to supply water from the river to the laboratory when experiments are being conducted in the open experimental channel. The 45.00 ms. length immediately behind the Abutment are supported on a concrete in mass raft

while the remainder is bedded in the existing ground. Two manholes were constructed to give access for silt clearance. The intake at the Abutment is fitted with a a two metres diam. sluice valve of exactly similar type to those at the Main Intake.

4) Control Chamber

This distributes the water comming either from the Main Experimental Channel or from the By-pass Inlet pipe to either the main laboratory through the venturimeter or to the small Exeperimental concrete by-pass channel. The chamber consists of a concrete tank with substantial concrete floor and walls.

5) Concrete By-Pass Channel

The U.S. end of the channel is stream lined in plan from a width of 2.00 ms. to 4.00 ms. The channel is rectangular in shape with 7:1 concrete floor and walls in which two expansion joints with standard copper seals are provided.

6) Measuring Tank

This is formed of a rectangular concrete tank divided into three tanks by reinforced concrete partition walls, each tank is connected with the other by means of an opening provided with a cast iron water tight penstock.

7) Main Sump and Outfall Culvert

The main sump is a continuation of the concrete by-pass channel and is similar to it. The outfall culvert leading from the main sump back into the Nile below the existing weir consists of twin seigwart pipes each one metre diam. having a fall of 60 cms. in the whole length.

This fall is built in limestone rubble masonry in 3 to 1 cement mortar on 7:1 concrete raft surrounded by M.S. sheet piling.

8) Progress of Work

The contractors programmed to start work on 5th January 1938 and to complete it on 15th. July 1938. Work was actually started on 10th January 1938 and proceeded intermittently for lack of materials and organization till late in August 1938, when the Contractors stopped work owing to the increased infiltration water.

The works which were completed during this period were :—

1— The floor of the measuring tank and main sump to the designed level.

2— The floor of the control chamber and by-pass channel to the designed level.

Work was resumed at the end of November 1938 and was entirely completed in September 1939.

It is noteworthly to mention the following points :—

A) **Consolidating the Foundations :—**

1) **Main Intake and Main Outlet**

The foundation being soft, was excavated lower than the contract level one metre at the intake and 65 cms. at the outlet. This was refilled with good selected sand.

2) **Control Chamber**

Only a few pockets of soft material were met with in excavating the foundation, and consolidation was done by dumping sand bags in these pockets and removing the soft material.

3) **Measuring Tank and Main Sump**

Small sized limestone rubble and ballast 30 cms. thick were dumped there-in with a view to consolidating the foundation and to prevent the inflow of silt.

4) **By-Pass Channel**

As the contractors failed to maintain the drains in a good working order, the subsoil water had no alternative but to flow below the portion of the already laid concrete withdrawing sand from underneath; two cracks developed in the floor, and the U.S. expansion joint was disturbed. The work was abandoned and when resumed a 2.00 ms. steel sheet piles diaphragm was driven at the scar to preclude the sand when excavating near by. The area between the cracks was treated by cutting 15 cms. thick from the surface and replacing it by a reinforced concrete slab tied down to the old concrete floor.

B) **Repairing Seigwart Pipes**

Some of the pipes delivered at the site were found to have fine hair cracks and so were put under water test.

Each pipe was supported on a trestle with its axis horizontal and a small brick wall was built at each end. About one third of the pipe was tested by pouring water inside. The pipe was then turned and a further section similarly treated.

It was agreed to cut a dove-tailed groove along the inside face of the pipe which was then filled with 2 : 1 cement mortar, but these repairs were not

always successful. Coating the inside surface of the pipes with three coats of sika and cement was found to be a positive treatment and was applied to all pipes after being laid in position.

ROADS

1) Design

A new road connecting the different parts of the works from the Eastern approach of the Tewfiki to the Western approach of the Behera had to be constructed.

The materials forming the embankments were deposited in 50 cms. layers and were rolled by a light roller 3-4 tons at least 3-6 months before the surfacing is deposited thereon.

2) Road Bed

As the embankments were brought up to approximately the final level, the width of the roadway was therefore excavated for a depth of 28 cms. to receive the limestone road bed after consolidating it with a 12·15 tons roller. The stones were set on edge, closely hand packed and rolled by the same roller to a solid hard core of about 22 cms. depth with an even surface and correct camber

3) Concrete Kerbs

Precast 4:1 fine concrete kerbs 30 cms. high by 20 cms. wide were set in place on each side of the road in 4:1 cement mortar, grouted and pointed. Steel moulds were used and the aggregate was 3/4" fine screened ballast.

4) Roadway Surface Materials

The aggregate for the roadway surface consisted of basalt from Abu Zabal; 5-3 cms. gauge for the bottom course, 2·1 cms. for the topping course and 1 cms. for the sealing coat. The filler consisted of 4.0 m/m. to dust of screened basalt crushings.

The bitumen for premixing was shelmac, and for sealing was 400/500 shelspra.

5) Mixing Roadway Surface Materials

a) Bottom Layer

A batch of aggregate was fed into a mechanical mixer, and bitumen heated to 95 °C was then added to the extent of 50 kgs. per one metre cube of aggregate and the whole were thoroughly mixed. Filler to the extent of 5% of the aggregate was added and mixing was continued until each particle of the aggregate was evenly coated with filler and bitumen.

b) **Topping Course**

The same procedure was followed, but the quantity of bitumen was increased to 60 kgs. per metre cube of aggregate.

6) **Laying Roadway Surface**

a) **Bottom Layer**

Prior to laying the bottom course, the road bed was swept clean and the premixed materials were then spread uniformly in a loose layer to the required camber and the depth of 8 cms. which was rolled down to 6.0 cms.

b) **Topping Course**

Premixed materials of the topping course was spread to an unconsolidated layer of 2½ cms. and rolled down to 1½ cms. The road was then opened for traffic.

c) **Sealing Coat**

A sealing coat of bitumen applied hot at 250°-280° C. by a pressure sprayer at the rate of 1.25 kg. per metre square. This coating was blinded with basalt chippings and rolled when cool. The road was again opened for traffic.

7) **Drainage of Roadway**

At intervals of about 50 metres rectangular C.I. box gulleys with outlets on the kerb side for 12½ cms, diam. reinforced concrete pipes were placed on each side of the roadway.

8) **Culverts Under Roads**

Culverts of reinforced concrete seigwart pipes of not less than 0.50 metre diam. with masonry heads were laid beneath the roadway embankments for passage of field irrigation channels where found necessary.

All macadam works were carried out by the Egyptian Road construction Company as subcontractors, and was finished in March 1940.

9) **Electric Light**

The Roads were provided with underground cables armoured with double layer of galvanized steel wire and with concrete lamp posts placed 80 metres apart at each side of the road. Posts on one side of the road were arranged to be midway

of the other side. These were carried out by Messrs Ateliers de Constructions Mecaniques de Charleroi under a separate contract under the control of the Mechanical and Electrical Dept. (P.W.M.).

The total cost amounted to :—

Cost of cables and accessories	L.E.	5,968
Cost of Stands.	„	2,032
Total . .	„	8,000

Owing to the prevailing unstable world conditions, it was impossible to supply the cables in time ready to be placed in position, and the main Contractors were given the option either to omit the work on the foot-paths or to do it during the maintenance period without extra cost, but as no definite answer was received it was decided to omit that portion of the work out of the contract.

The following are the dates on which the different parts of the works were started : –

Earth filling in	August	1938
Rubble Core	June	1939
Kerb moulding	June	1939
Building of kerbs	September	1939

INSPECTION OF WORKS

1) General

All materials and things to be supplied by the Contractors or Sub-Contractors were subject from time to time to inspection before being removed from their place of manufacture. The Contractors had to give three weeks notice in writing before any materials were proposed to be removed to the site.

All fees and charges in connection with the inspection, testings and analysis of materials were paid by the Contractors and the cost thereof is included in and covered by the schedule rates.

The Consulting Englineers frequently made inspection visits abroad and also appointed authorised inspectors.

The Contractors had also to provide at their own cost every thing necessary for testing and for the preparation of samples as well as for measuring the works including labour, materials, apparatus and things, as required by the Engineer.

2) Local Inspection

a) Concrete and Mesonry Inspectors

As the Contract is composed of a good number of subsidiary works beside the two main Barrages – Damietta, Rosetta and the Behera Regulator and as the execution was done concurrently it was essential to have a big staff of engineers for setting out, measurement and supervision, besides, a good number of checkers were employed for overseeing the proper gauging, washing, mixing of the concrete ballast recording the number of mixers per shift and for working the concrete while depositing etc.

In granite masonry a checker was appointed to supervise the work of two masons while in ordinary pitching one checker supervises four masons.

Masonry Inspectors were selected from among the engineers and each was helped by an Assistant Inspector for supervising the work of the checkers and the latter were selected from well trained checkers.

At each section there were three masonry inspectors, one for laying the concrete, another for masonry work and the third for pitching.

The checkers employed during the temporary work on the pile driving were shifted to the permanent work as much as the progress of the latter permits.

During the 2nd and 3rd seasons no night work was carried out but two shifts of eight hours each were sometimes allowed and this necessitated the employment of more checkers and making rotations between the masonry inspectors.

(b) Steel Work Inspectors

A steel work Inspector helped by two engineers acting as assistants together with checkers were employed during erection of all the steel work of sluice gates, lock gates, bridges ond fittings.

(c) Quarries Inspectors

A chief Quarry Inspector helped by two inspectors were employed together with the necessary number of checkers at the different quarries. An inspector was resident at Aswan for the granite quarries while the other was in charge of the limestone ballast and sand quarries near the works.

STAFF

The Consulting Engineers for the works were Messrs Coode, Wilson, Mitchel & Vaughan-lee and the partner in charge was Mr. A. G. Vaughan-lee who paid periodical visits and was commonly in touch with the works as weekly service letters and monthly reports were forwarded in time.

Two reports have been submitted to the Ministry by the Consulting Engineers during the whole period.

The Resident Engineer and his staff were under the Director General of Reservoirs Ahmed Bey Ragheb until Nov. 1938 when he was pensioned and his post was no longer occupied. The Resident Engineer was afterwards in direct touch with the Under Secretary of State.

Mohamed Bey Kamel Nabeeh was R.E. from the beginning of the works until 29.1.1938 when he was promoted to I.G.I.L.E. He was succeeded by Mahmoud Bey Mohamed Cararah for the 2nd and 3rd seasons.

The post of Assistant R. E. was occupied by Ibrahim Eff. Khalil Anis from the beginning of the works until 1.3.1938 when he was transferred and succeeded by Abdel Azim Eff. Ismail.

The Damietta Barrage together with the Tewfiki Regulator were entrusted to Ahmed Eff. Tewfik Tapozada.

The Rosetta Barrage together with the Nagayal Regulator were entrusted to Mahmoud Eff. Hassan Khater.

The Behera Regulator was entrusted to Hassan Eff. Mohamed.

Mr George Eric Chezlin Callow, was nominated by the C.E. to be Deputy R.E. and joined the works in 24.3.1938. He resigned the post in 31.12.1939.

(A complete list of the Government staff is appended).

The Contractor's Staff were :—

Mr.	F.H. Burkitt	Agent & Chief Engineer of the Works
»	P.C. Van Hauwaert	Personal Assistant
»	N. Goring	Sub Agent for Damietta
»	G. W. Rowland Owen	» » » Rosetta
»	H. De Broe	» » » Behera
»	P. Anhoury	Chief Electrical Engineer
»	J. Boff	Chief Mechanical Engineer

The sub-contractors, Agents were ;—

Mr. D. Parson representing Messrs. Ransoms & Rapier for the sluice gates.

Mr. P. W. Cramer Roberts representing Messrs. Head Wrighton for lock gates & Bridges.

COST

The total cost of the works amounted to L.E. 2404,661.844 excluding the claims of the main contractors. Details of this sum and its comparison with the contract Schedules is appended together with a comparison between contract and final quantities.

Appendix

COMPARISON BETWEEN CONTRACT

No.	SHORT DESCRIPTION	ROSETTA		DAMIETTA		BEHERA		TEWFIKI	
		Contract Q.	Final Q.	Contract Q.	Final Q.	Contract Q	Final Q.	Contract Q.	Final Q.
1	Cutting Out.			66	452		62	412	609
2	Excavation.	513.040	615.327	207.850	213.853	183.350	187.985	2.900	2.310
3	Excavation in Canal. .					710.500	587.362		
4	M.S. Sheet Piling. . . .	6.800	6.708	5.860	6.568	1.620	1.678		
5	Concrete 5 to 1. . . .	18.450	17.954	10.323	13.419	1.070	1.203	50	162
6	Concrete 6 to 1. . . .	13.665	13.560	8.915	8.886	1.250	1.253	970	1.011
7	Concrete 7 to 1. . . .	124.850	125.503	109.720	105.681	48.830	54 353	280	41
8	Concrete 8 to 1. . . .	4.680	4.245	3.590	3.274	910	826	427	700
9	Concrete 10 to 1. . . .								
10	Concrete 15 to 1. . . .	250	226	180	159	37	28	22	14
11	Concrete (fine granite) 4:1.	5.100	4.934	3.760	3,643	628	607	170	159
12	Concrete (fine screened) 4:1.	760	752	765	785	673	703	24	78
13	Concrete Blocks 6:1. .			1.190	1.177				
14	Concrete Blocks 7:1. .	19.400	19.412	17.060	16.448	3.450	3 359		
15	Moulded Concrete. . . .			200	192				
16	Reinforced Concrete. . .							280	228
17	Granolithic Paving. . .	1.980	1.918	2.140	1.947	1.650	1.633	120	120
18	Granite - Dressed. . . .	11.693	11.578	8.704	8.60	2 288	2.325	104	141
19	Granite Blockers.	6.090	5.943	4.960	4 461	2.220	2.091		
20	Granite Pitchers.	3.370	3.354	2.490	2.477	475	467	600	561
21	Limestone Dressed. . . .		43	1	6			148	140
22	Limestone Rubble Masonry.								
23	Limestone Pitching Mortar.	10.550	10.336	8.500	9.449	900	2.745	357	338
24	Limestone Pitching, Dry.	46 500	53.185	25.850	16 271	45.590	32.775	1.400	539
25	Limestone Rubble. . . .	2.400	310	3.80	3.989	7.000	13.131		
26	Brick Work.			7				221	491
27	Asphalt Brick Paving. .	3.792	3.777	2.852	2.837	590	580	360	342
28	Gravel Coating.	6.650	NIL	6.560	NIL	2.800	1.128		
29	Roadway & Foot Paths.								
30	Ramming Filling. . . .								
31	Concrete Pipes.								
32	Steel & Iron Work. . .	47	43.22	42.54	30	30	30.8	21	18.10
33	Penstocks & Valves. . .								

Rosetta includes the Barrage, the lock and the abutment.
Damietta » » » » » » » »
Minor works are the Road Bridges, Ancient Gateway and Roads.

BARRAGES.

No. I

AND FINAL QUANTITIES.

NAGAVEL		RESEARCH LAB.		MINOR WORKS		GRAND TOTAL		BALANCE	
Contract Q.	Final Q.	Contract Q.	Final Q.	Contract Q.	Final Q.	Contract Q.	Final Q.	+	–
			36	54	47	532	1.206	674	
5.300	3.475	28.000	27.251	16.545	5.641	956.985	1,055.842	98.857	
23.000	24.515					733.500	621.877		111.623
185	184	170	219	310	312	14.945	15.669	724	
						33.893	32.738		1.155
90	90	32				25.922	24.800		122
2.780	2.763	6.970	6.924	3.401	2.874	296.831	298.139	1.308	
230	221					9:837	9.266		571
				200	199	200	199		1
8	11			7	8	504	446		58
95	89		72			9.753	9.504	103.4	249
12	11.4		48			2.234	2,374.4		
						1.190	1.177		13
						39.910	39.219		691
				492	488	692	680		12
		74	59	315	301	669	558		81
46	45.77	250	243	215	148	6.401	6.123		278
209	197	112	107	304	282	23.414	23.230		184
215	209	70	55	110	108	13.665	12.867		798
60	56			25	25	7.020	6.940		80
		35	33	53	28	237	250	13	
		670	760			670	760	90	
2.900	2.778	620	333	5.600	2.193	29.427	28.172		1.255
2.900	2.907	1.500	1.524	28.000	22.528	150.740	127.678		23.062
			161			13.200	17.591	4.391	
		140	120	154	110	515	615	93	
210	210					7.804	7.464		58
70	NIL					16.080	1.128		14.952
				75.000	58.924	75.000	58.924		17.076
		130	902	134.200	147.325	134.330	158.227	23.897	
		615	597	1.502	963	2.117	1.560		557
1	0.88	72	58.90	43.9	41.9	261.9	226.34		25.56
		21	21			21	21		

Appendix No. II.

SUMMARY OF TOTAL COSTS COMPARED WITH CONTRACT-SCHEDULES

SECTION	Total Cost of Masonry		Total Cost of Steel		GRAND TOTAL	
	Actual L.E. m/ms	Schedule L.E. m/ms	Actual L.E. m/ms	Schedule L.E. m/ms	Actual L.E. m/ms	Schedule L.E. m/ms
Rosetta Barrage . . .	896,925.379	888,055.379	132,844.071	131,664.667	1,029,769.450	1,019,720.046
Damietta Barrage . .	707,149.695	711,469.160	99,910.859	98,871.667	807,060.554	810,340.827
Behera Canal and Reg.	284,188.016	248,233.987	47,697.857	46,704.666	331,885.873	294,938.653
Tewfiki Canal and Reg.	25,639.098	24,399.205	34,787.707	25,218.000	60,426.805	49,617.205
Nagayel Canal and Reg.	23,394.898	23,990.467	3,008.000	3,008.000	26,402.898	26,998.467
Hydraulic Research Lab.	41,676.172	41,401.076	—	—	41,676.172	41,401.076
Road Bridges. . . .	18,357.751	19,025.518	—	—	18,357.751	19,025.518
Ancient Gateway . .	3,021.653	2,675.517	—	—	3,021.653	2,675.517
Roads	32,552.212	45,327.516	—	—	32,552.212	45,327.516
Fittings	36,244.124	31,290.074	—	—	35,244.124	31,290.074
Drilling Holes and Grouting	—	4,275.300	—	—	—	4,275.300
Profit on Sub-Contractor . .	20,000.000	20,000.000	—	—	20,000.000	20,000.000
Miscellanious	783.960	—	—	—	783.960	—
Incrd. Cuts. duties. .	11,660.251	—	1,613.891	—	13,474.142	—
Contengencies . . .	—	10,0000.000	—	—	—	100,000.000
TOTAL . .	2,100,793.209	2,196,133.406	319,862.385	305,564.000	2,420,655.594	2,501,700.406
Credit in respect of cement delivered in paper bags	15,993.750	—	—	—	15,993.750	—
GRAND TOTAL . .	2,084,799.459	2,196,133.406	319,862.385	305,567.000	2,404,661.844	2,501,700.406

Appendix No. III

COMPARISON BETWEEN CONTRACT SCHEDULES AND ACTUAL COST

DESCRIPTION	Total Amount L.E. m/ms	Extra L.E. m/ms	Grand Total L.E. m/ms	Contract Schedule L.E. m/ms
		A. — Masonry		
Rosetta Barrage	642,759.587	1,666.182	644,425.769	647,889.093
Rosetta Lock	180,544.415	5,488.219	186,032.634	177,079.309
Rosetta Abutment	63,592.380	2,874.596	66,466.976	63,087.192
TOTAL	886,896.382	10028.997	896,925.379	888,055.594
Damietta Barrage	466,254.660	1,240 495	467,495 155	474,346.715
Damietta Lock	169,775.508	22,055.458	191,830.966	187,925 346
Damietta Abutments	46,674.040	1,149.534	47,823.574	49,197.099
TOTAL	682,704.208	24,445.487	707,149.695	711,469.160
Behera Canal and Regulator	266,590.863	17,597.153	284,188.016	248,233.987
Tewfiki Regulator	22,330.560	3,308 538	25,639.098	24,399 205
Nagayel Regulator	23,391.673	3.225	23,394 898	23,990.467
Hydraulic Research Lab.	39,822.360	1,853.812	41,676.172	41,401.076
Road Bridges	18,357.751	—	18,357.751	19,025.518
Ancient Gateway	2,729.112	292.541	3,021.653	2,675.517
Roads	28,976.603	3,575.609	32,552.212	45,327.516
Fittings	35,198.368	45.756	35,244.124	31,290.074
Drilling holes and grouting	—	—	—	4,275.300
Profit, etc., on work of Sub-Contract	20,000.000	—	20,000.000	20,000.000
Miscellaneous	—	783.960	783.960	
Contingencies	—	—	—	100,000.000
TOTAL	2,026,997 880	61,935.078	2,088,932.958	2,196,133.406
Increased Custom Duties	11,860.251	—	11,860.251	—
GRAND TOTAL	2,038,858.131	61,935.078	2,100,793.209	2,196,133.406
Credit in respect of cement delivered in paper bags	15,993.758	—	15,993.750	—
NET TOTAL	2,022,864.318	61,935.078	2,084,799.459	2,196,133.406
		B. — Steel Work		
Rosetta	132,679.860	164·211	132,844.071	131,689.667
Damietta	99,886.859	24.000	99,910.859	98,896.667
Behera	47,677.857	20.000	47,697 857	46,729.666
Tewfiki	33,798.000	989.707	34,787.707	25,243.000
Nagayel	3,008.000	—	3,008.000	3,008.000
	317,050.576	1,197.918	318,248.494	—
Increased Custom Duties	1,613.891	—	1,613.891	—
GRAND TOTAL	318,664.467	1,197.918	319,862.385	305,567.000

Appendix

COMPARISON BETWEEN CONTRACT SCHEDULES

ITEM	Rosetta Final Cost L.E. m/ms	Rosetta Cont. Sch. L.E. m/ms	Damietta Final Cost. L.E. m/ms	Damietta Cont. Sch. L.E. m/ms
A—Ransomes and Rapier Contract				
Sluice Gates	87,739.000	87,739.000	55,406.000	55,406.000
Operating Machines	16,460.000	16,460.000	16,460.000	16,460.000
Sundries	1,592.667	1,900.667	1,592.667	1,900.667
Extra Work	—	—	—	—
Increased Customs	—	—	—	—
TOTAL	105,791.667	106,099.667	73,458.667	73,766.667
B—Head Wrightson Contract				
Lock Gates	12,874.000	12,706.000	12,414.000	12,246.000
Swing Bridges	9,623 000	8,445.000	9,623.520	8,445.000
Capstans on Lock walls	494.000	494.000	494.000	494.000
Penstocks in Lock culverts	2,295.000	2,295.000	2,295 000	2,295.000
Stop Logs	954 672	1,003 000	954.672	10,003.000
Chequer Plate Covers	622.000	622.000	622.000	622.000
Hydraulic Jacks for Bridges	25.000	25.000	25.000	25.000
Extra Work	164.211	—	24.000	—
Increased Customs	—	—	—	—
TOTAL	27,052.404	25,590 000	26,452.192	25,130.000
GRAND TOTAL	132,844.071	131,689.667	99,910.859	98,896.667

No. IV

AND ACTUAL COST OF STEEL WORK.

Behera		Tewfiki		Nagayel		Total	
Final Cost. L.E. m/ms	Cont. Sch. L.E. m/ms	Final Cost L.E. m/ms	Cont. Sch. L.E. m/ms	Final Cost. L.E. m/ms	Cont. Sch. L.E. m/ms	Final Cost L.E. m/ms	Cont. Sch. L.E. m/ms
13,697.000	13,697.000	11,165.000	6,186.000	1,770.000	1,770.000	16,977.000	164,798.000
5,142.000	5,142 000	2,660.000	—	1,238.000	1,238.000	41,960.000	39,300.000
1,592.666	1,900.666	—	—	—	—	4,778.000	5,702.000
—	—	21.276	—	—	—	21.276	—
—	—	—	—	—	—	1148362	—
20,431.666	20,739.666	13,846.276	6,186.000	3,008.000	3,008.000	217,684.638	209,800.000
13,232.000	13,106.000	8,280.000	8,580.000	—	—	46,800.000	46,638.000
9,623.520	8,445.000	11,668.000	10,452.000	—	—	40,538.561	35,787 000
494.000	494.000	—	—	—	—	1,482.000	1,482.000
2,295 000	2,295.000	—	—	—	—	6,885.000	6,885.000
954.671	1,003 000	—	—	—	—	2,864.015	3,009.000
622.000	622.000	—	—	—	—	1,866.000	1,866.000
25.000	25.000	25.000	25.000	—	—	100.000	100.000
20 000	—	968.431	—	—	—	1,176.642	—
—	—	—	—	—	—	465.529	—
27,266.191	25,990.000	20,941.431	19,057.000	—	—	102,177.747	95,767.000
47,697.857	46,729.666	34,787.707	25,243.000	3,008.000	3,008.000	319,862.385	305,567.000

Contractors	Final Cost. L.E. m/ms	Cont. Sch. L.E. m/ms
Ransomes & Rapier	217,684.638	209,800.000
Head Wrightsons	102,177.747	95,767.000
GRAND TOTAL	319,862.385	305,567.000

Appendix No. V

MAIN PARTICULARS OF GROOVES AND SLUICE GATES

	Rosetta	Damietta	Behera	Tewfiki	Nagayel
Number of vents	46	34	6	6	2
Span of vents . . . . . M	8.00	8.00	8.00	5.00	3.00
Width of piers . . . . . M	2.50	2.50	2.50	2.00	1.50
Width of sluice well . . . M	1.80	1.80	1.80	1.00	1.10
Parapet level . . . . . R.L.	23.70	23.70	23.70	21.68	21.90
Sill Level . . . . R.L.	11.00	12.00	11.50	11.30	13.00
Grooves Top level . . . »	19.60	19.60	19.60	19.20	19.50
Total height . . . . M	8.60	7.60	8.10	7.90	6.50
Single . . . . M	2 x 2.50	2 x 2.50	3 x 2.50	—	—
M	1 x 3.00	1 x 2.00	—	—	—
Double . . . . M	1 x 0.60	1 x 0.60	1 x 0.60	2 × 3.334	3 × 1.90
M	—	—	—	1 × 1.15	1 × 0.80
Baseplate . . . . . M	—	—	—	1 × 0.082	—
Gates. Net height 2 leaves M	5.70	4.70	7.00	7.00	4.15
Height 1 leaf. . . . . M	2.90	2.40	3.55	3.55	2.124
Rollers per leaf No. . .	8	6	8	8	6
Rollers Diam. x face Inches	24 x 5½	24 x 5½	24 × 5½	15 × 4½	12 × 3½
Chains. Diam. »	1¼	1¼	1¼	1 1/16	7/8
Skinplate thickness . . .	5/8	5/8	5/8	½	½
Main joists. In	19 x 7½ x 4	19 x 7½ x 4	19 × 7¼ × 4	16 × 6	12 × 6
Side channels In	17 x 4½	17 x 4¼	17 × 4¼	15 × 4¼	12 × 4⅛
Staunching Bars	1⅛	1⅛	1⅛	15/16	1⅛
Weights per vent Tons					
Grooves & bolts	9.61	8.61	9.11	10.15	7.60
1) Beams, sprags, chequer plates	1.35	1.37	2.97	0.97	0.91
U.S. Gates with chains . . .	12.41	10.52	13.68	6.45	5.23
D.S. Gates with chain	12.11	10.01	12.96	6.38	
Total weight per vent . .	35.48	30.51	38.72	23.95	13.74

(1) Chequer plates at Rosetta & Damietta cover the piers only. Chequer plates at Behera, Tewfiki & Nagayel cover the whole vents and piers.

APPENDIX No. VI

LOCK GATE DATA

		Rosetta	Damietta	Behera	Tewfiki
Platform Level	R. L.	19.71	19.71	19.71	18·84
Top of Lock Wall	»	19.50	19.60	19.50	19.18
Top of Skinplate	»	19.00	19.00	19 10	18.84
Sill Level	»	11.00	12.00	10.50	10.68
Height of Gate above sill M.		8.00	7.00	8.60	8.16
Number of Decks		8	7	9	11
Type of Gate			Curved		Flat
Length, metre to heelpost centres M.			7.11		4.92
Depth of Girders, Maximum M.			1.14		0.37
Deck plating bottom	Inches		3/4		3/4
remainder	»		1/2		1/2
Skinplates Top 2 or 3 Spans			5/8		5/8
remainder	»		3/4		5/8
Diaphragms	»		1/4		—
Diagonal Straps	»		10 x 1/2		10 x 1/2
Type of Suspension			Concentric		Eccentric
Radius of Heelpost	M.		0.25		0.20
Weights per Gate	**Tons**				
Swinging Weight Steel		36.08	32.42	37.72	20.58
Greenheart		2.42	2.25	2.74	(1) 1.22
Total		38.50	34.67	40.46	21.80
Top Anchorage & Bottom Pivot		3.36	3.36	3.36	23
Chequer plates over top abchorages		.44	.44	.44	—
Operating gear & Gate arm		7.32	7.32	7.32	(2) 3.19
Chequer plates over operating gear		2.46	2.46	2.46	—
Gate Stops Greenheart 0.22 Ton		.34	.34	.34	—
Total Weight per gate	Tons	52.42	48.59	54.38	25.22

1) Metre & Sill only. Steel heelpost. 2) Average of Four.

Appendix VII

SWING BRIDGE DATA

	Rosetta Damietta Behera	Tewfiki
Roadway Level . . . . R.L.	22.40	21.20
Roller path bed level . . . . »	20.25	19.41
Roadway Width . . . . M	5.83	5.83
Width of each footpath 2 per bridge . . »	1.22	1.22
Radius to nose abutment . . . . »	19.30	19.31
» » tail » . . . . »	8.50	9.30
Width between centres of main girders . . .	14-0"	29'-6"
Depth of main girders over angles pivot & tail .	5-0"	7'-6"
» » » » » nose end . .	5-0"	6'-0"
Mean diameter of roller path	14-0"	19-0"
Number of rollers	24	32
Mean diameter of rollers	10"	10"
Length of rollers	1'-1"	1'-1"
Diameter of pivot pin bearing pad	1-3"	1'-3"
Operating gear Turns for 90° movement high gear	14.43	16.94
low »	43.30	41.95
Radius of end of capstan bars	6-0¼"	6-2⅝"

Weights per Bridge **Tons of 1016 Kgs.**		
Structural steel. Also trolley track & buffers Tewfiki	125.48	154.22
Operating & wedging gear	4.25	4.57
Upper roller path & wedges Pivot pin block . .	4.83	6.24
Kentledge blocks & bolts. (1) 3.45 tons more at Damietta.	139.45	132.89
Concrete 6.30 » » »	52.30	50.50
	326.31	347.42
Live ring & rollers	6.39	8.85
Total Moving Weight	332.70	356.27
Fixed portion. Pivot, wedge & roller bases, abutment Kerbs. Also trolley track, buffer stops, Tewfiki .	10.39	13.70
Total Weight	343.09	369.97

(1) Extra at Contractors' expense to compensate for unnecessary thickness of concrete on roadway.

TOTAL WEIGHTS IN TONS OF 1016 KGS.

	Rosetta	Damietta	Behera	Tewfiki	Nagayel
Grooves and groove bolts	442	293	55	61	15
Sprags, beams, chequer plate	62	46	18	9	2
Gates and chains	1128	698	159	74	10
	1632	1037	232	144	27
Operating machines and spares.	149	149	38	15	10
Gate and groove spares .	96	59	35	6	1
Temporary suspensions . .	4	4	—	—	—
Machine rails and girders.	—	—	—	—	—
	1881	1249	305	178	38
Machine rails, ladders, etc.(1)	52	39	7	—	2
Total weight Tons	1933	1288	312	178	40

(1) Items 661, 666, 683-685 and 687 of the 2nd Schedule.

WEIGHTS AND TOTAL COSTS

	Number of vents	Weight Tons	Cost (2) L.E.	Cost per Ton L.E.	Cost per Vent L.E
Rosetta Barrage	46	1933	113,490	58.7	2,467
Damietta Barrage	34	1288	78,436	60.6	2,307
Behera Regulator (3). . . .	6	312	20,411	65.4	3 402
Tewfiki »	6	178	15,181	85.3	2,530
Nagayel »	2	40	3,273	81.8	1.606
4 ton crane, spares and gate trolley	—	33	4,695	139.0	
Total		3785	235,486	62.2	

(2) Includes L.E. 1,148 customs refund, L.E. 14,270 proportion of L.E. 20,800 paid to main contractors for services to subcontractors, and L.E. 3,532 for cost of fittings supplied by the main contractors and directly connected with the sluice gates and operating machines.

(3) Includes cost of supplying 192 stoplogs, drying off vents, and removing old grooves, etc.

Total Weights per Lock Tons

	Rosetta	Damietta	Behera	Tewfiki
Gates as above 4	209.68	194.36	217.52	100.88
Penstock Sluices 6	38.08	37.38	33.41	—
» Chequer Plate Covers	1.83	1.83	1.88	(1) 0.99
Warping capstans with racks 2	4.81	4.81	4.81	—
Head Wrightsons Total	254.40	238.38	262.57	101.87
Subway, Tube, Ladders, Clips and Covers (2)	34.50	32.99	35.07	—
Fairleads, Bollards, Ringbolts, Ladders Lamps, Handrailing, etc. (3)	50.08	52.06	44.35	0.78
Total Weight per Lock Tons	338.98	323.43	341.99	102.65

(1) Covers over 2 D.S. operating gears.

(2) Items Nos. 170, 245, 385, 659, 665, and 669 of main schedule.

(3) Items Nos. 642/3, 649, 653, 655/6. 658-660, 662/3, 666-668 and 688/9 of main schedule.

Total Weights and Cost

	Weight Tons	Cost. (1) L. E.	Cost per Ton L. E.
Rosetta Lock	339	21,156	62,4
Damietta Lock	323	20,514	63,5
Behera Lock	342	21,217	62,0
Tewfiki Lock including extra work and quoins, etc.	103	9,917	96,6
80 Stoplogs for Vents	75	3,062	40,7
Total	1182	75,866	64,2

(1) Total cost is made up of L.E. 61,066 for 4th Schedule items and extras, L.E. 301 for proportion of Customs refund, L.E. 3,920 for proportion of L.E. 20,800 paid to main contractors for services a rendered to sub-contractors, and L.E. 10,579 for fittings in locks.

Total Weights and Costs

	Weight Tons	Cost (2) L.E.	Cost per Ton L.E.
Rosetta, Damietta & Behera Bridges (3)	*1039*	*31,231*	*30,0*
Tewfiki Bridge	*370*	*12,593*	*34,0*
Jacks, pump & piping	*0,49*	*107*	*218,4*
Total	*1409*	*43,931*	*32,1*

2) The total cost is made up of L.E. 40,647 for 4th. schedule items and extras, L.E. 165 for proportion of customs refund L.E. 2,609 for proportion of L.E. 20,800 paid to main contractors for services rendered to sub-contractors, and L.E. 510 for concrete on roadways and footpaths paid to main contractors.

3) Total weight includes 9,75 tons extra concrete and kentledge in Damietta bridge for which no payment was made.

GOVERNMENT STAFF LIST.

MOHAMMED ALY BARRAGES

RESIDENT ENGINEER — **M. Kamel Nabeeh Bey, 1st Season**; **M. M. Cararah Bey, 2nd and 3rd Season**

Technical Secr. — Moustafa Abboud.

Deputy R. E. — George E. C. Callow, 2nd and 3rd Season

Assistant R. E. — Ibrahim K. Anis, 1st Season; Abd El Azim Ismail, 2nd and 3rd Season

BEHERA
- Hassan Mohammed
  - Masonry & Concrete — Hassan Fathy El Dib
  - Settingout & Measurment — M. Hamid El Kordy

ROSETTA
- Moh. H. Khatir
  - Masonry & Concrete — Shahin Assad
  - Settingout & Measurment — Abdel Hakim Aly

DAMIETTA
- Ahd. Tewfik Topozada
  - Masonry & Concrete — Mohd. El Caramany
  - Settingout & Measurment — Hassan Maamoun

- Laboratory — Ibr. Z. Kinawi
- Steel Works — David Myles
- Quarries — Ahd. Said Ibrahim
- Drawing and Certificate Office — Abdalla Hassan
  - Engineers
  - Draughtsmen
- Colony — Mikael Girgis
- Photography — Mohd. Hilmy

ERRATA

Page	Line		To be replaced by
25	32	contructed	constructed
26	11	permeablc	permeable
27	14	acrossed	crossed
27	15	accross	across
27	36	outled	outlet
28	33	expence	expense
30	36	use	use in
41	20	is	is in
42	9	Granites	Granite
43	9-10	gentry	gantry
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78	36	fil	fill
82	31	Conraction	Contraction
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86	19	manufactureres	manufacturers
87	7	Heading	Heating
88	12	$C_a (OH)^2$	$C_a (OH)_2$
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102	8	sufficien	sufficient
103	18	fixe	fix
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104	28	lengtt	length
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115	5	sand and	sand
116	11	determiened	determined
116	26	tables below	following tables
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126	28	thls	this

Page	Line		To be replaced by
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133	27	similiar	similar
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135	26	ins	ins^2
138	3	King	Kind
140	2	King	Kind
142	8	in	it
142	24	Ouarrying	quarrying
142	35	lacated	located
146	28	Hydrauric	Hydraulic
147	2	arrea	area
148	5	pilling	piling
148	31	losk	lock
149	17	Larcens	Larssens
150	34	followipg	following
150	37	ta	to
151	10	coller	collar
151	36	paperet	parapet
152	35	cylinde	cylinder
155	11	seived	sieved
155	26	Constructian	Construction
157	3	fort he	for the
159	22	eonstructed	constructed
160	23	bondig	bonding
163	19	completety	completely
163	29	grainte	granite
164	18	fhe	the
167	5	same	same
167	5	proviously	previously
168	9	grounted	grouted
169	23	in in	in
169	36	from	form
170	20	diaphagm	diaphragm
170	21	comming	coming
170	28	have	has
171	25	Larseen	Larssen
172	29	atarted	started
173	32	aud	and
175	3,5	drivers	divers
175	17	wile	while
176	10	exctacted	extracted
177	19	o	to
178	29	ommitting	omitting
179	22	wish	with
180	12	ommitted	omitted
180	21	brult	built
181	12	transvers	transverse
181	29	comming	coming
184	25	statrted	started
185	2	duriug	during
188	14	securily	securely
190	34	comming	coming
191	5	For	for
192	26	he	the
192	32	Rewatering	Dewatering
193	2	extentnecessary	extent necessary
194	4	togethcr	together
195	15	hem	them
197	7	continious	continuous
198	15	he	the
200	32	When	when
201	18	leboratory	laboratory
202	3	a a	a
202	6	comming	coming
207	5	Mesonry	Masonry
220	1	Tons	in Tons
220	29	services a	services